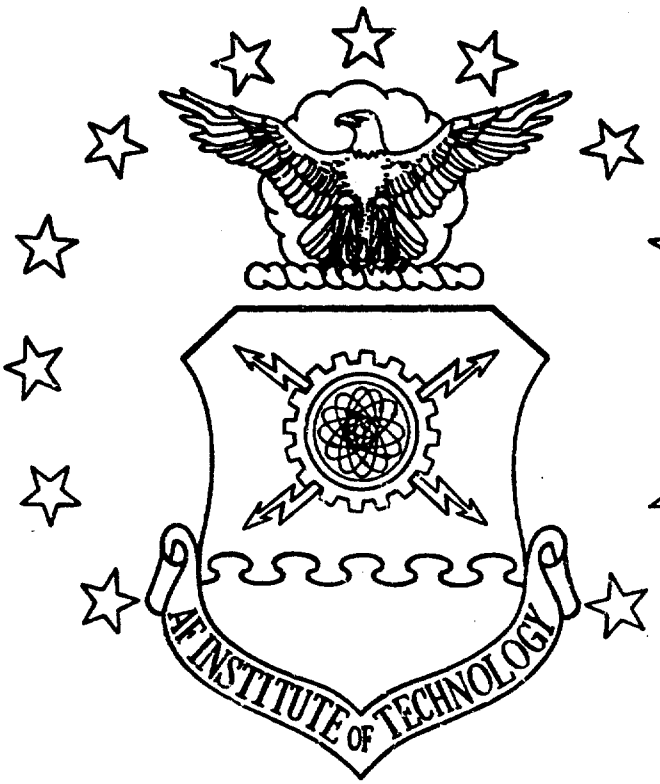

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This thesis presents an empirical evaluation of the outcomes of a large number of recently completed defense contracts. Profit outcomes and cost growth resulting from changes in the scope of the contract and from overrun/underrun are examined for incentive and fixed fee contracts. Incentive features such as share ratios and multiple incentives are investigated to determine their effect on contract outcomes. Linear regression and analysis of variance techniques are used to analyze the outcomes of 2683 Army, Navy, and Air Force contracts. The types of contracts included in the data sample are fixed-price incentive, cost-plus-incentive-fee, and cost-plus-a-fixed-fee contracts. No meaningful relationship is found to exist between cost overrun/underrun and changes in the scope of the contracts analyzed. The contract change percentage is found to decrease as the contractor's portion of the share ratio increases. Also, incentive contracts with large contractor share rates are found to have a tendency to overrun. An examination of multiple incentive contracts reveals that contracts with performance incentives, as well as cost incentives, tend to earn performance incentives, regardless of the contract cost outcome.

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AN EXAMINATION OF RECENT DEFENSE CONTRACT OUTCOMES IN THE INCENTIVE ENVIRONMENT

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Captain USAF

AN EXAMINATION OF RECENT DEFENSE CONTRACT OUTCOMES IN THE INCENTIVE ENVIRONMENT

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology

Air University

in Partial Fulfillment of the
Requirements of the Degree of
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by

John M. Parker, Jr., B.S.A.E.
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Preface

I wish to express my appreciation to Lt. Col. David L. Belden, my thesis advisor, for initially encouraging my interest in the defense procurement process. His conscientious counsel and critique throughout the research and completion of this thesis were invaluable to me. I am also deeply indebted to Maj. Ronald Quayle for his valuable contributions to my understanding of the statistical analyses used in this report.

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John M. Parker, Jr.

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Abstract

This thesis presents an empirical evaluation of the outcomes of a large number of recently completed defense contracts. Profit outcomes and cost growth resulting from changes in the scope of the contract and from overrun/underrun are examined for incentive and fixed fee contracts. Incentive features such as share ratios and multiple incentives are investigated to determine their effect on contract outcomes. Linear regression and analysis of variance techniques are used to analyze the outcomes of 2683 Army, Navy, and Air Force contracts. The types of contracts included in the data sample are fixed-price incentive, cost-plus-incentive-fee, and cost-plus-a-fixed-fee contracts. No meaningful relationship is found to exist between cost overrun/underrun and changes in the scope of the contracts analyzed. The contract change percentage is found to decrease as the contractor's portion of the share ratio increases. Also, incentive contracts with large contractor share rates are found to have a tendency to overrun. An examination of multiple incentive contracts reveals that contracts with performance incentives, as well as cost incentives, tend to earn performance incentives, regardless of the contract cost outcome.

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AN EXAMINATION OF RECENT DEFENSE CONTRACT OUTCOMES IN THE INCENTIVE ENVIRONMENT

I. Introduction

The stated purpose of incentive provisions in defense contracts is to communicate to a contractor the value placed on various aspects of contract performance by the customer (U.S. Government). Incentive contracting is intended to motivate the contractor to perform in the best interests of the government. Incentive contracting is based on the government assumption that profit is the main motivating force of the contractor. The Incentive Contracting Guide, issued jointly by the Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) states:

> The Guide recognizes that profit is the basic motivating force behind incentives, but realizes that contractors in maximizing profit do not necessarily seek "maximum" profit on every contract even if they could. Those "extracontractual motivators" (e.g., follow-on business, growth, image, etc.) should be considered in structuring the contract. However, DoD and NASA accept the concept that these factors are often beyond the control of the Government and willingly subscribe to the philosophy that to the degree that a contractor can be motivated by profit to produce more efficiently, he is achieving the government's objective (Ref 42:ix).

Statement of the Problem

The Department of Defense has placed strong emphasis on the use of contracts containing incentive provisions as a means of reducing procurement costs of defense hardware. The problem faced in the research of this thesis is to determine if significant changes in defense contract cost and profitability outcomes have resulted from increased DoD

emphasis on incentive type contracts.

Numerous studies have been completed concerning incentive contracting results. The General Accounting Office (GAO) has published reports on various aspects of defense procurement, resulting mainly from Congressional interest. DoD has explored this area in detail, primarily through directed studies performed by non-profit research organizations on contract to the Government, such as the Logistics Management Institute (LMI) and the Rand Corporation. Another important source of incentive contracting analysis is faculty and student research in colleges and universities. A representative sample of previous research studies concerning incentive contracting can be found in Appendix A.

Objective of the Research

The objective of this research is to provide a comprehensive empirical analysis of recent defense contract outcomes in the incentive environment. Through this analysis, a number of questions concerning incentive contract results may be examined. Much interest is continually focused on defense procurement, since it involves such large amounts of our national income and resources.

Questions Concerning Incentive Contracting

Has the increased emphasis on incentive contracting resulted in a change in the relative mix of contract types? Has the increased emphasis on incentive contracting resulted in changes in contract cost growth, including changes in contract scope and cost overruns/underruns?

To answer these general questions, more specific questions must be asked. The analysis pertaining to these specific questions constitute the primary objective of this research. These are the same questions

Dr. David L. Belden proposed about contract outcomes in his study of defense procurement (Ref 3:15,16). However, the additional data available for fiscal years 1968 through 1970 provides a much larger data base for examination of these questions. The basic areas examined are contract growth outcomes, contract profit outcomes, incentive combination outcomes, and extracontractual costs and benefits.

Contract Growth Outcomes

1. Is there a significant relationship between authorized contract changes and overruns/underruns?

2. What is the relationship of contract growth and contract type: FPI, CPIF, and CPFF?

3. What is the relationship of contract growth and the size of the automatic incentive sharing ratio?

4. What is the relationship of contract growth and the type of work, i.e., production or research and development?

Contract Profit Outcomes

5. Is there a difference in average profit among the different types of contracts?

6. What is the relationship of average profit and the various automatic incentive sharing ratios?

7. Is there a difference in average profit between contracts for production and contracts for research and development?

Incentive Combination Outcomes

8. What is the relationship between incentive outcomes on multiple incentive contracts?

Extracontractual Cost and Benefits

9. Have there been extracontractual costs and benefits resulting

from the incentive environment?

Approach to the Problem

The contents of Chapter I have generally outlined the problem statement of the research, and some pertinent questions concerning the problem. Chapter II provides background and definitions necessary to understand incentive contracting theory. The recent era of the "incentive environment" is examined and significant areas noted. Chapter III introduces the methodology used in this research and presents an analysis of DoD contract cost growth. Chapter IV presents an analysis of contract profits for DoD contracts.

In Chapter V, the results of the analysis are summarized, and a discussion of the results is included.

II. The Incentive Environment

In Chapter I the philosophy of the Department of Defense regarding contractor motivation was quoted from the Incentive Contracting Guide. The basic premise that there are other motivational factors for the contractor than profit is acknowledged, but since the other factors are basically intangible, the DoD will use an incentive system based on profit.

Historical Perspective

The United States has historically achieved superiority in military balance with her actual or potential enemies through the use of private enterprise to produce military hardware. In colonial times the Americans relied mainly on foreign military aid to build their arsenal and defenses (Ref 1:176). The subsequent years saw civilian production of small arms increase. The armsmakers could readily transfer production to military needs as the situation demanded, and sell to the government at a firm price, fixed in competition. The growing shipbuilding industry began producing the first real "weapons system" - the warship. Warships were produced both by private and Naval shipyards. Private shipyards entered into competitive bidding for naval warships, and by the time of the Civil War, there was serious competition between private and government owned shipyards for the production of naval ships. Critics of private shipyards pointed out that ships would be built for "higher cost" in the private yards than in the publicly-owned, military-run yards. Private producers quickly replied by pointing out the superior product produced in the private yards. The result of this competition was ultimately a "lower cost" for private production, and a

"higher quality" product from public shipyards (Ref 17:40,41).

The confrontation between the warships Monitor and Merrimack off the coast of Hampton Roads, Virginia highlights the initial use of an incentive provision in a contract for a military weapons system. The Merrimack was built in the Norfolk Naval Yard, a public shipyard. The Monitor was built by private industry to government specifications, using a fixed-price negotiated contract with the incentive provision that payment was provided only if the Monitor floated, attained a minimum specified speed, and won its first battle. Although the Monitor and Merrimack battle ended in a draw, and certain other provisions of the contract were not met, the contractor was paid the full $275,000 price, including a profit of $80,000 (Ref 17:41;Ref 3:8).

By the time the United States entered World War I, military contracts for various weapons systems were being used. The airplanes, ships, submarines, and tanks which were used in World War I required large government expenditures to produce them. The switch from peacetime to wartime production was ill coordinated, and emergency measures were employed. Private industry was converted to wartime production, but many problems arose which made this conversion a slow process. The government launched a program to build and finance defense plants on a large scale, and furnished equipment to contractors to meet defense needs. The pressing need for defense hardware caused a new type of contract to be introduced as an emergency measure. This contract stipulated development and production of war goods at cost-plus-a-percentage-of-cost. Various measures were used to limit excess profit due to cost escalation. Maximum fees were specified, sliding scales were used which reduced the fee percentage as the cost grew, and

bonuses were provided for cost reductions (Ref 17:42,43).

Following World War I, the need for industrial mobilization and stockpiling for defense was apparent, and various government agencies set up plans to prevent a recurrence of the World War I fiasco. Nearly twenty years of peace following World War I saw most of the mobilization plans discarded.

The major technical advances in weapons systems which followed World War I were primarily in aviation. The procurement of aircraft was based on competitive prototype testing. The contractor risked losing the competition both in terms of cost and performance. In actual fact, the Air Corps usually bought all prototypes in order to insure that the contractors would continue in business. These prototype purchases usually did not exceed $600,000 (Ref 17:44). This concept of "fly-before-you-buy" has recently been reemphasized and will be treated later in more detail.

The involvement of the United States in World War II again taxed the capacity and inventiveness of American industry in providing modern armaments. The difficulties of changing from a peacetime to a wartime economy were again encountered. The War Production Board, an independent civilian agency, was formed in 1942 to procure goods and services for the military services. Formal advertising was eliminated during the war years as a procurement technique. Negotiated contracts calling for firm fixed prices, redeterminable fixed prices, and cost-plus-a-fixed-fee were extensively used. The renegotiation of contract prices was an innovation that was accepted as a result of wartime conditions.

The "Armed Services Procurement Act of 1947" resulted from

Congressional pressure to return to defense procurement through formal advertising and to regulate the expanding purchase of defense hardware in the marketplace. This law formed the basis for defense procurement practices in use from then until today. These practices are assembled in the Armed Services Procurement Regulation (ASPR) (Ref 14:14,15).

In the decade following World War II, the United States began to assemble a strong military organization, equipped with the most advanced weaponry possible in the light of existing technical knowledge. The industrial base for this technical superiority became very large and specialized.

The Incentive Era

The passage of the National Security Act of 1947 established a new service, the Air Force. It also created the position of Secretary of Defense to administer the National Defense Establishment. In 1949, the centralized responsibility for national defense was further clarified when Congress created a Department of Defense (DoD) with increased centralized authority over the three services (Ref 24:72,73).

Former Secretary of Defense Robert S. McNamara firmly instituted the "incentive era" when he purposefully established guidelines and regulations to govern DoD procurement. Belden defines the beginning of an incentive environment as July 1, 1962, the beginning of fiscal year 1963. Belden points out three specific management actions which initiated this era. These are (Ref 3:4):

1. The administrative ceiling on profits for certain types of contracts was eliminated.

2. The Armed Services Procurement Regulation (ASPR) was rewritten

to emphasize preference for fixed-price and incentive contracts.

3. The Cost Reduction Program was formulated to include an emphasis on fixed-price and incentive contracts.

This research will use Belden's definition of the beginning of the incentive environment. Fiscal year 1963 is designated as the beginning of the incentive environment.

Era of Transition. The announced goal of increased emphasis on fixed-price and incentive contracts resulted in a definite substitution of fixed-price and incentive contracts for cost-plus-a-fixed-fee contracts, as shown in Table I.

The percentage of cost-plus-a-fixed-fee contracts (including no-fee type), in terms of procurement dollars, dropped from slightly less than 40% in fiscal year 1961 to less than 15% in fiscal year 1964. In the same period, firm-fixed-price and fixed-price incontive contracts rose from less than 45% to nearly 65% of contract awards. The cost-plus-an-incentive-fee type of contract in that period rose from about 3% to over 14% of contract awards. The subsequent contract award mix from Table I can be seen to have stabilized near the fiscal year 1964 percentages. This does not imply that the area of defense procurement has been unchanging since 1964. This only indicates the continuing emphasis which has been placed on the use of firm-fixed-price and incentive contracts.

Incentive Contracts

The increased emphasis on incentive contracts as a means of controlling cost and improving contractor performance is based on the assumption that if a contractor shares the risk associated with contract performance, he will be motivated more strongly toward a successful

TABLE I

AWARDS BY TYPE OF CONTRACT PRICING PROVISION

AS A PERCENTAGE OF TOTAL CONTRACT DOLLARS (FY 1959-1970)[a]

Type of Pricing Provision[b]	Fiscal Year											
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Fixed Price Type (Sub-Total)	59.1%	57.4%	57.9%	60.8%	64.9%	71.2%	76.5%	79.2%	78.9%	77.6%	75.8%	74.0%
Firm	32.8	31.4	31.5	38.0	41.5	46.3	52.8	57.5	56.3	52.7	50.2	47.5
Incentive	15.3	13.6	11.2	12.0	15.8	18.5	16.6	15.9	17.8	18.7	19.7	20.9
Other[c]	11.0	12.4	15.2	10.8	7.6	6.4	7.1	5.8	4.8	6.2	5.9	5.6
Cost Reimbursement Type (Sub-Total)	40.9	42.6	42.1	39.2	35.1	28.8	23.5	20.8	21.1	22.4	24.2	26.0
Incentive	3.2	3.2	3.2	4.1	11.7	14.1	11.2	8.3	8.3	9.0	9.3	9.8
Fixed Fee	34.3	36.8	36.6	32.5	20.7	12.0	9.4	9.9	10.4	10.8	9.6	10.4
Other[d]	3.4	2.6	2.3	2.6	2.7	2.7	2.9	2.6	2.4	2.6	5.3	5.8
Total Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total Dollars (In Billions)	$22.9	$21.2	$22.9	$25.8	$26.2	$25.3	$24.3	$33.5	$39.2	$39.1	$37.2	$36.0

[a] Source: Military Prime Contract Awards, various issues (Ref 41).
[b] Represents procurement actions of $10,000 or more excluding Intragovernmental.
[c] Includes Redeterminable and Escalation.
[d] Includes No Fee and Time and Materials.

outcome. Success basically involves contract outcomes which meet or are below target costs and which produce a product which meets or exceeds target performance. Incentive theory allows a contractor to be rewarded for a successful outcome, and penalized for an unsuccessful outcome (Ref 16:3-5).

The rewards and penalties of incentive contracts are primarily related to increases or decreases in profit. Appendix B describes the four basic types of contracts used in defense procurement. These are the firm fixed-price (FFP), fixed-price incentive (FPI), cost-plus-incentive-fee (CPIF), and cost-plus-a-fixed-fee (CPFF) contracts. The firm fixed-price contract is thought to provide the contractor with the greatest reward or penalty, as well as the most motivation toward effective contract management. The contractor under a FFP contract assumes full responsibility for costs associated with the contract. The extreme opposite situation is the use of a cost-plus-a-fixed-fee contract, where the Government assumes responsibility for all allowable contract costs, and the contractor is guaranteed a fixed fee, regardless of contract outcome. The fixed-price incentive and cost-plus-incentive-fee contracts fall between the two extremes, and the FPI and CPIF contracts both provide for negotiated incentive provisions to enhance contractor motivation.

Incentive Provisions

The Department of Defense instructs its contract negotiators to consider extracontractual incentives in awarding and structuring defense contracts (Ref 42:2). Some of these extracontractual incentives are: follow on business, increased profit margin on the other contracts through overhead absorption, the nation's international reputation,

company prestige and goodwill, maintenance of capability, and professional excellence. While recognizing these factors, DoD has no pragmatic method of including extracontractual provisions in a contract. The prevalent method of contractor motivation used in contract negotiation is to provide incentive provisions which are based on the profit motive. In CPIF and FPI contracts the share ratio technique is used to define Government and contractor responsibility for cost. A 70/30 share ratio, for example, is a percentage ratio which means the customer (U.S. Government) accepts responsibility for 70% of costs above or below target cost, and the contractor assumes responsibility for 30% of the cost above or below target. The limitation of a ceiling price is imposed under a FPI contract, and the CPIF contract limits sharing over a range of incentive effectiveness (RIE).

The concept of incentive provisions has not been limited to cost incentives. Both CPIF and FPI contracts may include <u>multiple incentives</u>. A multiple incentive contract provides product performance and/or schedule targets, in addition to target costs. The Incentive Contracting Guide states (Ref 42:107):

> Multiple incentive contracting combines the motivation for technological progress, timely delivery, and effective cost control with the ultimate objective of attaining an appropriate balance between performance, schedule, and cost control -- not necessarily the lowest cost. Obviously, in cost-only incentives, the emphasis is on the attainment of the stated performance achievement at the lowest cost.

In theory, multiple incentives encourage beneficial tradeoffs between the factors of cost, performance, and schedule. The incentive provisions of the contract should be structured to communicate the Government's objectives to the contractor. The incentive provisions

motivate the contractor to make tradeoffs which are beneficial to the Government, since Government benefit will vary directly with the interests of the contractor.

POESMIC. The Program Office for Evaluating and Structuring Multiple Incentive Contracts (POESMIC) was formed as a DoD agency in April, 1968. This office is assigned the responsibility to assist DoD and NASA procurement officials in structuring multiple incentive contracts to communicate the Government's objectives to the contractor. The military services require all multiple incentive contracts over $5,000,000 to be structured using the services of POESMIC. Some factors identified as adversely affecting multiple incentive arrangements are improper ranges of incentive effectiveness, improper choice of target levels of non-cost incentive parameters, multiple share ratios, and complex or discontinuous formulas and graphs (Ref 15:1-3). The POESMIC approach to multiple incentive contract structuring is the use of computer programs which use iterative procedures to develop incentive arrangements. The products of this iterative process are tradeoff curves, nomographs, and cost-performance-schedule ordering tables.

Current DoD Incentive Practice

In March 1971, before a House of Representatives subcommittee reviewing DoD appropriations for 1972, Secretary of Defense Melvin R. Laird said:

> "We (DoD) are proposing that primary development reliance be placed on cost-incentive contracts. This will enable us to base development schedules on development milestones rather than on specific points in time. We believe that once development programs have been completed in a satisfactory way, fixed price contracting should normally be used for production

> contracts. After the parameters of a product have been carefully established and demonstrated in the development stage, contract negotiations to establish a fixed price production contract can be conducted on a sound basis" (Ref 35:125).

David Packard, the Deputy Secretary of Defense, has emerged as the central DoD figure in the management of defense procurement (Ref 11:24). Before the same Congressional subcommittee, Secretary Packard outlined the current DoD policy on defense procurement which has been termed "fly-before-you-buy". Packard explained this policy as follows (Ref 36:18):

> "It is clear that discussions of the policy of fly-before-you-buy often have over-emphasized a literal interpretation and under-emphasized its real meaning. I strongly subscribe to the concept and will apply it in a meaningful way to all major projects. In my mind, fly-before-you-buy means having an acceptable level of confidence that we know what we are doing before we move ahead. It means development problems are in hand before we do engineering. It means engineering is ready before we go into production. It means we have confidence in the need for the capability before we enter into any of these phases. It means the management plan is sound and the costs are described and controlled. Within these meanings, we must have the objective of fly-before-you-buy on all of our programs."

The Department of Defense has formalized the concepts outlined by Secretary Packard in Department of Defense Directive Number 5000.1 (Ref 40). Major programs to be designated by the Secretary/Deputy Secretary of Defense will be managed on a milestone basis, with program progress subject to Secretary of Defense level review and approval. Conceptually, this procedure decentralizes and streamlines program management, with DoD acting primarily as a review and final approval authority.

This new policy cannot be evaluated at this time, since no major

procurement actions have been recently completed using the milestone or fly-before-you-buy approach. The General Accounting Office (GAO) identified the main causes of cost growth on 52 major programs as estimating, engineering changes, and economic factors (Ref 13:21). The new weapons system acquisition policy is aimed at improving procurement practice in those and other areas. It should be noted here that the analysis for this research does not include contracts which have been awarded under the fly-before-you-buy policy.

Concluding Comments

The enormous costs associated with maintaining a "peacetime" defense capability have historically been a matter of public and political concern. However, the rapid demobilization that occurred following World War I was not repeated following World War II. The "cold war" threat spurred technological achievement, and defense became more costly, complex, and specialized. This chapter has emphasized the need for a variety of contract types, and has pointed out the theoretical benefits of incentive provisions in defense contracts. The following chapters examine actual contract outcomes in an effort to determine what effect the increased DoD emphasis on FFP and incentive type contracts has had on the defense procurement process.

III. Contract Outcomes - Cost Growth

The results of an analysis of contract outcomes for a large number of defense contracts are presented in this and the following chapter. This chapter presents an analysis of contract cost growth, while the following chapter considers profit on defense contracts.

Cost growth of defense contracts is classified either as contract change due to changes in the scope of the contract or as cost overrun/underrun.

A brief Logistics Management Institute survey of government contracting personnel revealed four general motives for their use of incentive contracts (Ref 16:3). These motives are as follows:

(1) Incentives motivate efficient contract management and achievement of a high performance product.

(2) Incentives enable the Government to reward contractors on the basis of demonstrated management ability and product performance.

(3) Incentives assign to the contractor a larger portion of contract risk than he would bear with a CPFF contract.

(4) Incentives provide explicit communication of the Government's contracting objectives.

These four statements form a concise statement of incentive theory. It follows that DoD policy stressing increased use of incentives should, in theory, result in a reduction in the likelihood and occurrence of cost overruns. An evaluation of this theory is made using statistical tests based on empirical data.

The methodology used in evaluating contract outcomes was developed by Belden in his previously cited research (Ref 3). The basic difference in this analysis is the greater number and currency of contracts available for study.

Belden's sample contained 834 contracts, whereas the increased sample contains 2683 contracts.

Description of Data

The data on defense contracts used in this analysis was obtained from the DD Form 1500 "Record of Contract Completion", submitted by defense contractors in accordance with the Armed Services Procurement Regulation (ASPR). The requirements for completion and submission of DD Form 1500 are contained in the ASPR. The data submitted by the contractor is subject to authentication and audit by the Government (Ref 39:para. 21-401a).

The DoD Directorate for Information Operations compiles a summary of the information on the DD Form 1500. This summary was used in this analysis. The data elements used and an explanation of each element is as follows:

Department:	Army, Navy, or Air Force.
Type of Contract:	FPI, CPIF, or CPFF (FFP contracts are not included in the analysis since data on cost and profit is not available on this type of contract).
Type of Work:	Production or Research & Development.
Award Year:	Fiscal year of contract award.
Completion Year:	Fiscal year of contract completion.
Initial Cost:	Originally negotiated cost (target).
Initial Profit:	Originally negotiated profit (target).
Adjusted Cost:	Initial cost plus the algebraic sum of all subsequent formal contract cost changes.
Adjusted Profit:	Initial profit plus the algebraic sum of all subsequent formal contract profit changes.
Final Cost:	Actual cost of the work.
Final Profit:	Actual profit for the work.

Sample Description

Contracts were selected for inclusion in the data sample based upon various selection criteria. These criteria include constraints on contract elements such as year of award, year of completion, type of contract, and dollar size of contract. The contract sample includes only contracts which were awarded and completed in the period beginning with fiscal year 1963 and ending in fiscal year 1970. The incentive era was previously defined as having been initiated in fiscal year 1963. Table II presents a breakout of the total sample of 2683 contracts according to fiscal year of award and fiscal year of completion.

TABLE II

CONTRACT SAMPLE BY YEAR OF AWARD AND YEAR OF COMPLETION

	Completion Year								
Award Year	63	64	65	66	67	68	69	70	TOTAL
63	7	53	54	64	108	106	26	10	428
64		13	64	82	125	124	54	13	475
65			12	68	151	167	76	23	497
66				13	148	221	172	47	601
67					24	164	163	57	408
68						39	119	60	218
69							12	43	55
70								1	1
TOTAL	7	66	130	227	556	821	622	254	2683

The types of contracts considered consist of FPI, CPIF, and CPFF contracts. FFP contracts were not included in this analysis since complete data on cost and profit for firm fixed-price contracts is not available. In addition, contracts for services or construction were excluded from the sample. The contracts studied involved procurement of major hardware items including aircraft, missiles, ships, ammunition, and electronics equipment. There were 1064 production contracts and 1619 research and development contracts in the sample. The contracts are termed defense contracts because they include only Army, Navy, and Air Force contracts. The numbers of contracts in each classification are summarized in Table III.

Only contracts having an initial price (cost plus profit) or final price over $200,000 are included in the contract summary data compiled by DoD. This limitation is, therefore, extended to the contract sample. Table IV shows the incremental distribution of contracts by price. Although final and adjusted price are both on the order of nine and a half billion dollars, they are about 1.5 billion dollars or nearly 20% higher than the initial negotiated price.

Contract Growth Defined

The term contract growth is used in this research to refer to two seperate elements. The first element is change, which implies a change in the scope or target cost in the contract prior to contract completion. These changes become part of the contract. Contract change is defined as:

$$\text{Change } \% = \frac{Ca - Ci}{Ci} \times 100 \qquad (1)$$

TABLE III

CONTRACT SAMPLE BY TYPE OF CONTRACT, WORK, AND SERVICE

Variable	Subdivision	Number of Contracts
Type of Contract	FPI	439
	CPIF	448
	CPFF	1796
Type of Work	Production	1064
	R & D	1619
Service	Army	1152
	Navy	579
	Air Force	952
TOTAL		2683

TABLE IV

CONTRACT SAMPLE BY INITIAL, ADJUSTED, AND FINAL PRICE

Price Range ($ in Thousands)	Number of Contracts		
	Initial Price	Adjusted Price	Final Price
$ < $ 200	417	86	42
200≤ < 400	696	779	803
400≤ < 600	335	391	396
600≤ < 800	188	212	205
800≤ < 1,000	130	138	149
1,000≤ < 5,000	648	739	747
5,000≤ < 10,000	114	161	164
10,000≤ < 25,000	101	108	111
25,000≤ < 50,000	36	40	38
50,000≤ < 100,000	13	23	21
100,000≤	5	6	7
TOTAL	2683	2683	2683
TOTAL DOLLARS	7.97 Billion	9.53 Billion	9.54 Billion

where Ca is adjusted contract target cost; and

Ci is initial contract target cost.

The second element is overrun/underrun, and implies an actual cost different from the target cost existing at the time of contract completion. When expressed as a percentage, underrun is defined as a negative overrun. Overrun is defined as:

$$\text{Overrun } \% = \frac{Cf - Ca}{Ca} \times 100 \qquad (2)$$

where Cf is final contract cost.

Table V shows the average contract change and overrun by type of contract and by type of work.

Change and Overrun/Underrun for Three Types of Contracts

As shown by Table V a, the average change for 2683 defense contracts is 66.0%, whereas the average overrun is only 3.0%. The CPFF contracts have the largest change, but the smallest overrun. CPIF contracts exhibit the greatest overrun. CPIF overruns average 7.1%, while FPI and CPFF contracts average only 2.6% and 2.1%, respectively. Figure 1 presents the distribution of overrun/underrun percentages for each type of contract.

As Table VI shows, over one-third of the contracts have outcomes which neither underrun or overrun their target, while over two-thirds of the contracts are within ±5% of their adjusted target costs. There is considerable variation between contract types. For example, 80% of

TABLE V

AVERAGE CONTRACT CHANGE AND OVERRUN

a. Data by Type of Contract

Type of Contract	Number	Mean Change	Mean Overrun
FPI	439	19.5%	2.6%
CPIF	448	34.9	7.1
CPFF	1796	85.1	2.1

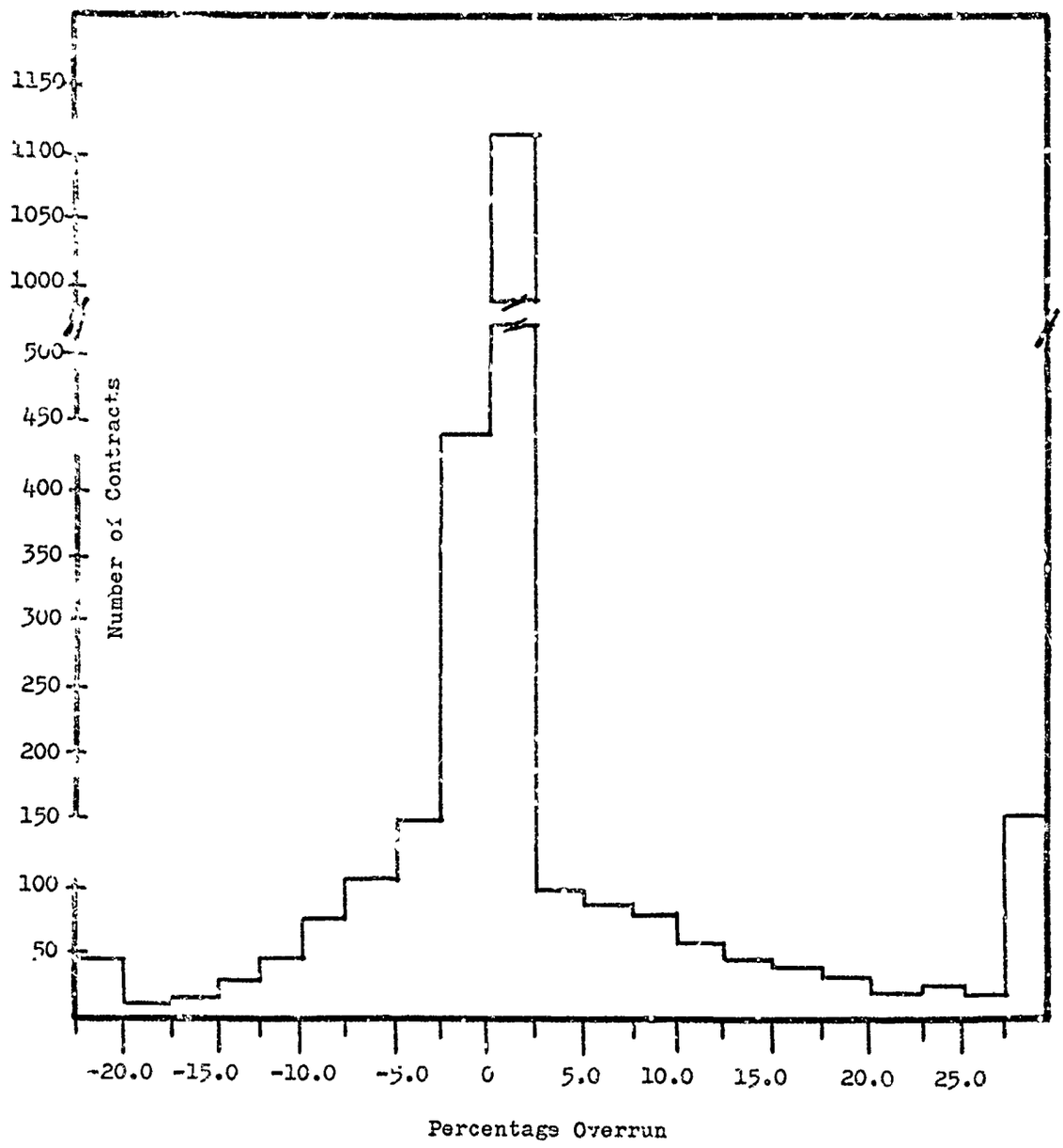
b. Data by Type of Work

Type of Work	Number	Mean Change	Mean Overrun
Production	1064	51.9%	1.5%
Research & Development	1619	75.3	4.0
COMBINED TOTAL	2683	66.0%	3.0%

the CPFF contracts fall within ±5% of target cost, while only 37% of the FPI contracts fall in this area. Also, 48% of the CPFF contracts have final cost that is equal to the adjusted cost. Only 4% of the FPI contracts are on-target. The outcomes appear nearly evenly divided between overruns and underruns.

Change and Overrun/Underrun for Two Types of Work

The two types of work considered in this research are production and research and development (R & D). The distribution of overruns for each type of work is shown in Figure 2. As shown in Table V b,



(Interval designations are lower limits)

	-20.0	-15.0	-10.0	-5.0	0	5.0	10.0	15.0	20.0	25.0
FPI (439)	15	3	7	8	18	30	32	41	40	51	29	26	29	21	20	15	9	5	5	8	17
CPIF (448)	7	6	5	8	12	24	35	28	72	83	19	17	16	13	11	10	8	8	4	3	59
CPFF (1796)	26	6	5	14	10	22	41	80	321	983	46	39	31	22	13	16	15	7	13	7	79
TOTAL (2683)	48	15	17	30	40	76	108	149	433	1117	94	82	76	56	44	41	32	20	22	18	155

Fig. 3. Distribution of Overruns for FPI, CPIF, and CPFF Contracts.

TABLE VI

PERCENT OF CONTRACTS WITH

SPECIFIC OVERRUN/UNDERRUN PERCENTAGE

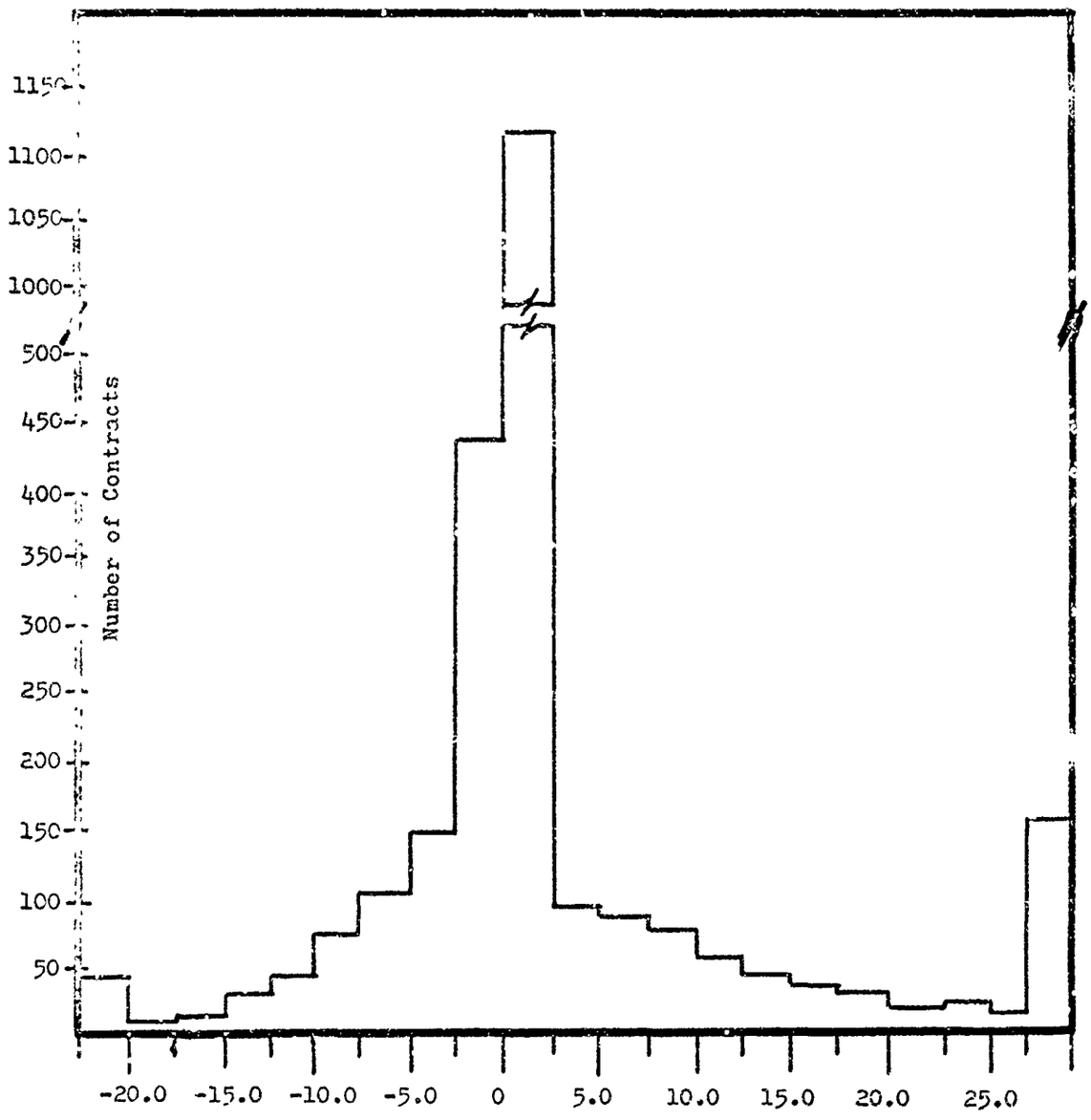
VARIATION FROM TARGET

	±5% of Target	±2.5% of Target	0%	Number Considered
FPI	37%	21%	4%	439
CPIF	45	35	12	448
CPFF	80	73	48	1796
Prod.	55	43	19	1064
R & D	75	67	45	1619
TOTAL	67	58	35	2683

research and development contracts average greater change and overrun than do production contracts. Table V illustrates that the greatest change occurs for CPFF contracts and R & D contracts, and the greatest overrun occurs for CPIF contracts and R & D contracts. Table VI shows that R & D contracts tend to meet or fall within ±5% of target considerably more often than production contracts.

Relationship of Contract Change and Overrun/Underrun

Incentive theory provides for reduced potential overruns by motivating the contractor to control costs and improve efficiency. Another possible means of reducing potential overruns is to increase the target cost through contract scope changes. One method to investigate the relationship between contract change and overrun/underrun is



(Interval designations are lower limits)

PROD (1064)	36	11	13	27	28	53	74	82	187	271	45	40	34	31	20	18	17	8	6	9	54
R & D (1619)	12	4	4	13	12	23	34	67	246	846	49	42	42	25	24	23	15	12	16	9	101
TOTAL (2683)	48	15	17	30	40	76	108	149	433	1117	94	82	76	56	44	41	32	20	22	18	155

Fig. 2. Distribution of Overruns for Production and R & D Contracts

to assume a linear relationship between overrun % and change % as follows:

$$\text{Overrun \%} = a + b\ (\text{Change \%}) \tag{3}$$

where a and b are unknown regression coefficients.

Regression coefficients were first calculated for the total sample of 2683 contracts. No relationship between change and overrun/underrun is evident at a meaningful statistical level of confidence for the total sample. Five other tests were made on the sample by dividing the contracts according to type of contract and by type of work. The results of these tests are shown in Table VII.

The null hypothesis that contract overrun/underrun is closely related to contract change is rejected for statistically significant levels of confidence for tests of the total sample, sample divided according to type of contract, and divided according to type of work.

Analysis of Variance of Cost Growth

In Table V evidence is shown that the mean change and mean overrun/underrun vary considerably between types of contracts and between types of work. A two-way analysis of variance was used to determine if the variation is statistically significant. The use of a two-way analysis of variance eliminates statistical confounding of the results. As an example, Belden points out that the average percentage change for any particular type of contract should be independent of the percentage change due to type of work (Ref 3:79). The unequal cell size model for two-way analysis of variance proposed by Snedecor was used throughout this research (Ref 30:484-488).

TABLE VII

REGRESSION COEFFICIENTS FOR SIX TESTS WITH OVERRUN/UNDERRUN PERCENTAGE AS THE DEPENDENT VARIABLE AND CHANGE PERCENTAGE AS THE INDEPENDENT VARIABLE

Contract Group	a	b	Standard Error of b	Null Hypothesis Rejection Level
2683 FPI,CPIF,&CPFF	3.1048	-0.0015	0.0014	0.31
439 FPI	2.8152	-0.0089	0.0149	> 0.50
448 CPIF	7.2031	-0.0039	0.0146	> 0.50
1796 CPFF	2.1449	-0.0007	0.0012	> 0.50
1064 Production	1.4912	-0.0004	0.0023	> 0.50
1619 R & D	4.2054	-0.0025	0.0018	0.17

Contract Change. The null hypothesis that mean changes are equal for the three types of contracts and that mean changes are equal for the two types of work was tested at the 1% level of significance. The results of this two-way analysis are summarized in Table VIII.

Note from Table VIII b that the null hypothesis was rejected for differential due to type of contract, while it was not rejected for the difference due to type of work. Thus, contract cost growth due to changes in the scope of the contract is significantly different according to the type of contract. This is consistent with incentive theory regarding choice of contract type, considering uncertainty as a major factor in contract selection.

The adjusted difference due to type of work shown in Table VIII c is -1.30%. This means that the average production contract change

TABLE VIII

ANALYSIS OF VARIANCE OF CONTRACT CHANGE FOR

2683 FPI, CPIF, AND CPFF CONTRACTS

a. Number, Mean Percentage Change, and Standard Deviation

Type of Contract	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
FPI	363	19.1%	46.6%	76	21.5%	69.3%
CPIF	215	28.2	63.8	233	40.6	80.4
CPFF	486	86.9	285.6	1310	84.5	247.4

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	890.89	890.89
Contract	2	1699336.72	849668.36 **
Interaction	2	18706.22	9353.11
Within	2677		46020.50

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: -1.30%

	FPI	CPIF	CPFF
Adjusted contract means	19.1%	34.7%	85.5%

percentage is 1.30% less than the average change percentage for R & D contracts. The contract means, adjusted for the difference due to type of work, are 19.1%, 34.7%, and 85.5% for the FPI, CPIF, and CPFF contracts, respectively, Note that these values are very close to the values for the unadjusted means shown in Table V a.

Contract Overrun/Underrun. The null hypothesis that mean overruns/underruns are equal for the three types of contracts and that mean overruns/underruns are equal for the two types of work was tested at the 1% level of significance. The results of this two-way analysis of variance are summarized in Table IX.

Table IX b indicates that the null hypothesis is rejected at the 1% level for type of contract and for type of work. Therefore, pricing arrangement and type of work are significant indicators of overrun as a percentage of adjusted cost. Production contracts have an average overrun percentage value 3.57% less than R & D contracts, as shown in Table IX c. Also note that CPIF contracts have a mean overrun of 7.00%, while FPI and CPFF average overruns are 1.49% and 2.89%, respectively.

Change and Overrun/Underrun for Incentive Contracts

The total sample of 2683 defense contracts was reduced to a smaller sample of 726 contracts having cost incentives. This smaller sample of 391 FPI and 335 CPIF contracts was divided into three groups according to the size of the contractor's portion of the incentive share ratio. The group intervals are: 15% or less, more than 15% but not greater than 30%, and more than 30%.

Although the share ratio is not specified on the DoD "Record of Contract Completion", it may be constructed from the data available in

TABLE IX

ANALYSIS OF VARIANCE OF CONTRACT OVERRUN/UNDERRUN

FOR 2683 FPI, CPIF, AND CPFF CONTRACTS

a. Number, Mean Percentage Overrun/Underrun, and Standard Deviation

Type of Contract	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
FPI	363	2.0%	14.0%	76	5.8%	22.9%
CPIF	215	3.7	19.7	233	9.9	24.6
CPFF	486	0.1	12.6	1310	2.8	13.1

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	6744.92	6744.92 **
Contract	2	11279.31	5639.66 **
Interaction	2	1045.08	522.54
Within	2677		237.34

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: -3.57%

	FPI	CPIF	CPFF
Adjusted contract means	1.49%	7.00%	2.89%

the DoD contract summary data. The amount of final contract profit used in the following equation is adjusted to reflect only cost incentives. The contractor's share, α, is given by:

$$\alpha = \frac{Pf - Pa}{Ca - Cf} \times 100 \qquad (4)$$

where Pf is final contract profit;

Pa is adjusted contract profit;

Ca is adjusted contract cost; and

Cf is final contract cost.

Table X shows that there were 237 contracts identified as having contractor's share ratios less than or equal to 15%. The average contractor's share ratio for this group is 9.1%. There were 203 incentive contracts with share ratios larger than 30%, with the average share being 45.3%.

TABLE X

AVERAGE AND STANDARD DEVIATION OF SHARING PERCENTAGE

FOR EACH OF THREE GROUPS OF INCENTIVE CONTRACTS

Sharing Limits	Number of Contracts	Average Share	Standard Deviation
$\alpha \leq 15\%$	237	9.1%	4.0%
$15\% < \alpha \leq 30\%$	286	22.0	4.4
$30\% < \alpha$	203	45.3	16.1
COMBINED TOTAL	726	24.3%	16.9%

Table XI gives the average percentage change and the average percentage overrun/underrun for each of the three share ratio groups.

TABLE XI

AVERAGE CHANGE AND OVERRUN/UNDERRUN FOR EACH OF THREE GROUPS OF INCENTIVE CONTRACTS

Sharing Limits	Average Change	Average Overrun/Underrun
$\alpha \leq 15\%$	35.1%	12.3%
$15\% < \alpha \leq 30\%$	25.2	0.5
$30\% < \alpha$	20.4	5.2
COMBINED TOTAL	27.1%	5.7%

Contract Change. The average change from initial target cost to adjusted target cost for these 726 incentive contracts is 27.1%. The group of contracts having a contractor's share ratio of 15% or less has an average change of 35.1%, the largest change of all groups. Those contracts with contractor's share of 30% or more have an average change of 20.4%. To determine if the difference in average change percentage between groups is statistically significant, a two-way analysis of variance was again used. The three groups of contractor's share ratios, and the type of work were considered as factors.

The null hypothesis that the mean change is equal for the three groups of share ratios, and for types of work was tested at the 1% level of significance. The null hypothesis was rejected for types of work. As shown in Table XII c, production contracts average percentage change

TABLE XII

ANALYSIS OF VARIANCE OF CONTRACT CHANGE

FOR 726 INCENTIVE CONTRACTS

a. Number, Mean Percentage Change, and Standard Deviation

Contractor's Sharing Percentage	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
$\alpha \leq 15\%$	138	28.4%	72.3%	99	44.5%	83.5%
$15\% < \alpha \leq 30\%$	199	18.3	36.9	87	41.0	82.4
$30\% < \alpha$	162	21.6	56.9	41	15.8	45.3

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	29572.7	29572.7 **
Share Ratio	2	15897.9	7948.9
Interaction	2	17663.3	8831.7
Within	720		3967.1

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: -13.9%

	$\alpha \leq 15\%$	$15\% < \alpha \leq 30\%$	$30\% < \alpha$
Adjusted α group means:	34.0%	22.5%	16.3%

is 13.9% less than R & D contracts for contracts having cost incentives. The null hypothesis cannot be rejected, however, for the three groups of contracts divided according to contractor's share ratio. Thus, type of work, and not size of share ratio, is the significant indicator of the percentage change of an incentive contract's initial cost.

Overrun/Underrun. The average overrun/underrun for incentive contracts in the group of 726 contracts is 5.7%, as shown in Table XI. However, the group of contracts with the least contractor sharing has an average overrun of 12.3%, while the group of contracts with sharing between 15% and 30% has an average overrun of only 0.5%. To test for equality of mean overrun/underrun percentages, and to eliminate confounding, a two-way analysis of variance was used. The null hypothesis that the average overrun/underrun percentages are equal for types of contracts and for types of work was tested at the 1% level. The results are given in Table XIII.

The null hypothesis is rejected at the 1% level for both ranges of sharing and for type of work. The adjusted difference in mean percentage overrun/underrun is found in Table XIII c to be 8.3%. Thus, production incentive contracts average significantly less overrun than R & D contracts. The largest overrun occurs for contracts in the group having the smallest values of α. An average underrun occurs for contracts with sharing between 15% and 30%, while those with an α greater than 30% average a 2.74% overrun.

Regression of Sharing Ratio, Overrun/Underrun, and Change

To determine if there is a statistically significant relationship between the size of the contractor's share ratio and the percentage of cost overrun, a linear regression analysis was applied. The relationship

TABLE XIII

ANALYSIS OF VARIANCE OF CONTRACT OVERRUN/UNDERRUN

FOR 726 INCENTIVE CONTRACTS

a. Number, Mean Percentage Overrun/Underrun, and Standard Deviation

Contractor's Sharing Percentage	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
$\alpha \leq 15\%$	138	6.7%	24.3%	99	20.0%	32.9%
$15\% < \alpha \leq 30\%$	199	-1.5	9.9	87	5.2	14.5
$30\% < \alpha$	162	4.7	17.2	41	7.5	29.5

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	10476.5	10476.5 **
Share Ratio	2	14968.4	7484.2 **
Interaction	2	2659.0	1329.5
Within	720		425.6

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: -8.3%

	$\alpha \leq 15\%$	$15\% < \alpha \leq 30\%$	$30\% < \alpha$
Adjusted α group means:	11.57%	-1.09%	2.74%

investigated is given by:

$$\text{Overrun } \% = a + b\,\alpha \qquad (5)$$

Where α is contractor's sharing percentage; and

a and b are unknown regression coefficients.

The increased emphasis on incentive contracting during the incentive era is based on the assumption that the more responsibility a contractor has for cost, the more he will attempt to control costs. The result would be decreased overruns. In equation 5 this would be reflected by a negative value for the coefficient b.

Eight groups of incentive contracts, numbered 1 through 8 in Table XIV, were originally identified for linear regression analysis. The first group consisted of the entire sample of 726 incentive contracts. The others are FPI and CPIF contracts, production and R & D contracts, and three groups divided according to contractor's sharing rate. Three of the eight groups have a negative slope, indicating decreasing overruns with increasing sharing. The null hypothesis that there is significant correlation between overrun and sharing rate, α, cannot be rejected at a high level of significance for two of these groups. CPIF contracts and contracts with α of 15% or less both tend to have a decrease in overrun as the share rate increases, with rejection levels of less than 1%. The null hypothesis rejection level is below the 1% level for the positive correlation shown for production or FPI contracts, as well as for contracts having large contractor share ratios. Thus, an increase in sharing for these three groups of

TABLE XIV

REGRESSION COEFFICIENTS FOR TWELVE TESTS WITH OVERRUN/UNDERRUN PERCENTAGE AS THE DEPENDENT VARIABLE AND CONTRACTOR'S SHARE RATIO AS THE INDEPENDENT VARIABLE

Contract Group		a	b	Standard Error of b	Null Hypothesis Rejection Level
1.	726 FPI & CPIF	5.28	0.016	0.047	> 0.50
2.	499 Production	- 0.71	0.133	0.045	0.004
3.	227 R & D	15.04	-0.149	0.119	0.21
4.	391 FPI	-11.26	0.430	0.044	< 0.001
5.	335 CPIF	19.19	-0.667	0.127	< 0.001
6.	237 $\alpha \leq 15\%$	32.26	-2.200	0.448	< 0.001
7.	489 $\alpha > 15\%$	- 9.75	0.385	0.042	< 0.001
8.	203 $\alpha > 30\%$	-27.39	0.718	0.072	< 0.001
9.	137 Production ($\alpha \leq 15\%$)	20.29	-1.470	0.489	0.003
10.	362 Production ($\alpha > 15\%$)	-11.69	0.396	0.041	< 0.001
11.	99 R & D ($\alpha \leq 15\%$)	49.13	-3.266	0.800	< 0.001
12.	128 R & D ($\alpha > 15\%$)	- 6.36	0.424	0.113	< 0.001

contracts is significantly associated with increased overruns.

The results of the original eight tests suggested further study. Four additional regression groups, numbered 9 through 12 in Table XIV, were constructed from the contract sample. Production and R & D contracts were divided according to sharing rate. Both production and R & D contracts with contractor's sharing rates of 15% or less have a decreasing tendency toward overruns as α increases. Production and R & D contracts with α greater than 15% exhibit an increasing tendency to overrun as α increases. The null hypothesis is rejected at less than the 1% level for all four cases.

To examine the correlation between contract change and contractor's share ratio, linear regression tests were performed on the first eight groups previously examined. The relationship investigated is given by:

$$\text{Change } \% = a + b\,\alpha \qquad (6)$$

where α is contractor's sharing percentage; and

a and b are unknown regression coefficients.

It has been proposed that defense contractors with a large financial responsibility in the outcome of the contract, i.e., a large contractor sharing rate, tend to recoup losses through change orders and revised contract specifications (Ref 27:53). The results of the eight tests shown in Table XV do not support this viewpoint. The only case in which the null hypothesis was rejected at less than the 1% level was for the total sample of incentive contracts. Generally, the change percentage for the entire sample of incentive contracts tends to decrease

TABLE XV

REGRESSION COEFFICIENTS FOR EIGHT TESTS WITH CHANGE PERCENTAGE AS THE DEPENDENT VARIABLE AND CONTRACTOR'S SHARE RATIO AS THE INDEPENDENT VARIABLE

Contract Group	a	b	Standard Error of b	Null Hypothesis Rejection Level
726 FPI & CPIF	36.13	-0.372	0.139	0.008
499 Production	27.34	-0.199	0.143	0.17
227 R & D	50.47	-0.620	0.336	0.07
391 FPI	27.96	-0.234	0.158	0.14
335 CPIF	36.88	-0.133	0.372	> 0.50
257 $\alpha \leq 15\%$	34.94	0.035	1.260	> 0.50
489 $\alpha > 15\%$	31.89	-0.277	0.157	0.08
203 $\alpha > 30\%$	28.63	-0.184	0.238	0.44

as the contractor's share ratio increases.

Multiple Incentive Contract Outcomes

Incentive contracting cannot be thought of only in terms of cost incentives. The concept of multiple incentives as pointed out in Chapter II provides the opportunity for beneficial tradeoffs. The Government's objective in the use of multiple incentives is optimization of the Government's benefit, concurrent with contractor optimization of his profit position.

A qualitative inference can be drawn from the DoD contract summary data concerning multiple incentives. This summary identifies contracts which gained or lost performance and/or schedule incentives. The results

of this analysis are shown in Table XVI. These results confirm and strengthen Belden's findings that: (1) performance incentives are earned more frequently than lost, and (2) performance incentives are earned regardless of the cost incentive outcomes (Ref 3:92).

Of the incentive contracts identified as having schedule incentives, the schedule incentives tend to be lost more often than gained. For contracts earning schedule incentives, 61% also earned cost incentives, 11% lost cost incentives, and 28% met their target cost. A noticeable trend is that contracts earning schedule incentives tend to underrun, and contracts losing schedule incentives tend to overrun. These results are summarized in Table XVII.

Comparison With Previous Research

Two previous in-depth studies of defense contract cost growth are compared here with the results of this research, shown in Table XVIII.

Fisher (Ref 7) reported on 874 FPI, CPIF, and CPFF Air Force contracts which were completed during fiscal years 1959 through 1966. Belden's (Ref 3) study involved 834 Army, Navy, and Air Force FPI, CPIF, and CPFF contracts awarded and completed during fiscal years 1963 through 1968. Belden's definitions of change and overrun are identical to those in this chapter. However, Fisher used a different convention in his computations, which is as follows:

$$\text{Change } \% = \frac{Ca - Ci}{Cf} \times 100 \text{ ; and} \tag{7}$$

$$\text{Overrun } \% = \frac{Cf - Ca}{Cf} \times 100 \tag{8}$$

TABLE XVI

OUTCOMES ON CONTRACTS HAVING COST AND

PERFORMANCE INCENTIVES

Cost Outcomes	Performance Incentives Earned	Lost
Underrun	18	3
On Target	7	5
Overrun	25	13
TOTAL	50	21

TABLE XVII

OUTCOMES ON CONTRACTS HAVING COST AND

SCHEDULE INCENTIVES

Cost Outcomes	Schedule Incentives Earned	Lost
Underrun	11	3
On Target	2	3
Overrun	5	20
TOTAL	18	26

TABLE XVIII

CHANGE AND OVERRUN FOR FPI, CPIF, AND CPFF CONTRACTS

AS FOUND BY FISHER, BELDEN, AND PARKER

Type of Contract	Fisher[a]	Belden[b]	Parker[c]
	Change		
FPI	4.17%	24.1%	19.1%
CPIF	77.15	48.4	34.7
CPFF	60.08	74.3	85.5
	Overrun/Underrun		
FPI	- 3.8%	0.8%	1.5%
CPIF	1.29	1.3	7.0
CPFF	1.90	2.7	2.9

a. (Ref 7:70,74)
b. (Ref 3:81,83)
c. Tables VIII and IX

where Ci, Ca, and Cf are the same as previously defined. For purposes of comparison, Fisher's results for change and overrun provide only a qualitative result for comparison due to the difference in definition.

Contract change for FPI contracts showed a substantial increase from the period of Fisher's study to that of Belden's study. This trend appears to be slightly reversed in the current sample. Also, CPIF contracts exhibit a marked trend toward a decrease in percentage change, while CPFF contracts continue to show a trend of increasing change. CPIF contracts also show a substantial increase in average overrun from the earlier results.

The relationship between incentive share and cost growth for types of contracts was found by Fisher and Belden not to be significant at any meaningful statistical level. The relationships shown in Table XIV for types of contracts are basically the same as found by Fisher and Belden. However, these relationships were found in this research to be statistically significant. The FPI contracts evidence a positive value for the regression coefficient, b, whereas this coefficient for the group of CPIF contracts is negative. The primary difference between the data samples used in this research and the two earlier samples is number and currency of contracts.

Conclusions

The analysis of defense contract cost growth presented in this chapter supports the following conclusions:

1. No meaningful relationship exists between overrun/underrun and contract change (Table VII).

The theory that contractors may attempt to reduce potential overruns by increasing target costs through changes in the scope of the contract is not supported.

2. Significant differences in average overrun/underrun exist for types of contracts and types of work (Table IX).

CPIF contracts average substantially larger overruns than do FPI and CPFF contracts. R & D contracts average larger overruns than do production contracts.

3. Generally, the contract change percentage of incentive contracts tends to decrease as the contractor's share rate increases (Table XV).

The theory that contractors with a large responsibility for cost

outcomes attempt to recoup losses through change orders and revised specifications is not supported. A negative relationship exists between contract change and contractor share, significant at the 1% level.

4. Contracts with large contractor share rates ($\alpha > 15\%$) tend to overrun (Table XIV).

This conclusion directly conflicts with the incentive theory that the more responsibility a contractor has for cost, the more he will be motivated to control costs, resulting in a reduced potential to overrun. This result implies a deficiency in the determination of contract incentive provisions.

5. Contractors tend to earn performance incentives, regardless of contract cost outcome (Table XVI).

This conclusion implies that contractor motivation may be inclined more toward quality than toward cost.

6. Underruns tend to be associated with early product delivery, and overruns tend to be associated with late product delivery (Table XVII).

This result is more an observation than a conclusion. It does imply, however, that cost and schedule incentives are not independent.

The results of this research reveal some significant developments when contrasted with the results of earlier research. CPIF contracts have substantially smaller changes, but significantly larger overruns. Also, the conclusive relationship between incentive share and cost growth found in conclusion 3 and 4 was not found to be significant in earlier studies.

IV. Contract Outcomes - Profit

Any examination of contract outcomes would be incomplete without including an examination of profit. Profit is viewed by DoD as the basis for incentive provisions in defense contracts. The actual profit earned on a contract is termed coming-out profit and is a function of other elements of the contract. These elements include target (going-in) profit, contractor's sharing rate, contract change, and overrun/underrun. This chapter parallels Belden's methodology for examination of contract profit outcomes (Ref 3:98).

The distribution of going-in and coming-out profit for different types of contracts is examined. Also, the statistical significance of profit differences appearing between types of contracts and types of work is discussed. The relationship between profit, share ratio, and cost growth is also examined. As in Chapter III, analysis of variance and regression tests are primarily used in the analysis.

The determination of a "fair" profit on defense contracts is considered as essential as the choice of contract type. ASPR 3-808 points out that "the best industrial capabilities will be driven away from the defense market if defense contracts are characterized by low profit opportunities". The Department of Defense has adopted a technique called the Weighted Guidelines Method to assist contracting officers in determining equitable going-in profit rates. This method assigns a specific weight to such factors as the contractor's input to total contract performance, the type of contract, contractor's overall performance, and financing arrangements (Ref 31:100). DoD policy implies that this method will allow contractors that assume higher

risk to benefit through higher profits.

Profit Definitions

Profit is generally reported for DoD contracts in terms of profit dollars or profit rato, i.e., profit dollars as a percentage of cost dollars. Coming-out profit rate is given by:

$$\text{Coming-Out Profit Rate (\%)} = \frac{Pf}{Cf} \times 100 \qquad (9)$$

and profit dollars for the simple cost incentive case is given by:

$$Pf = Pa + \alpha\,(Ca - Cf) \qquad (10)$$

where Pf is coming-out profit dollars;

Pa is going-in profit dollars (adjusted);

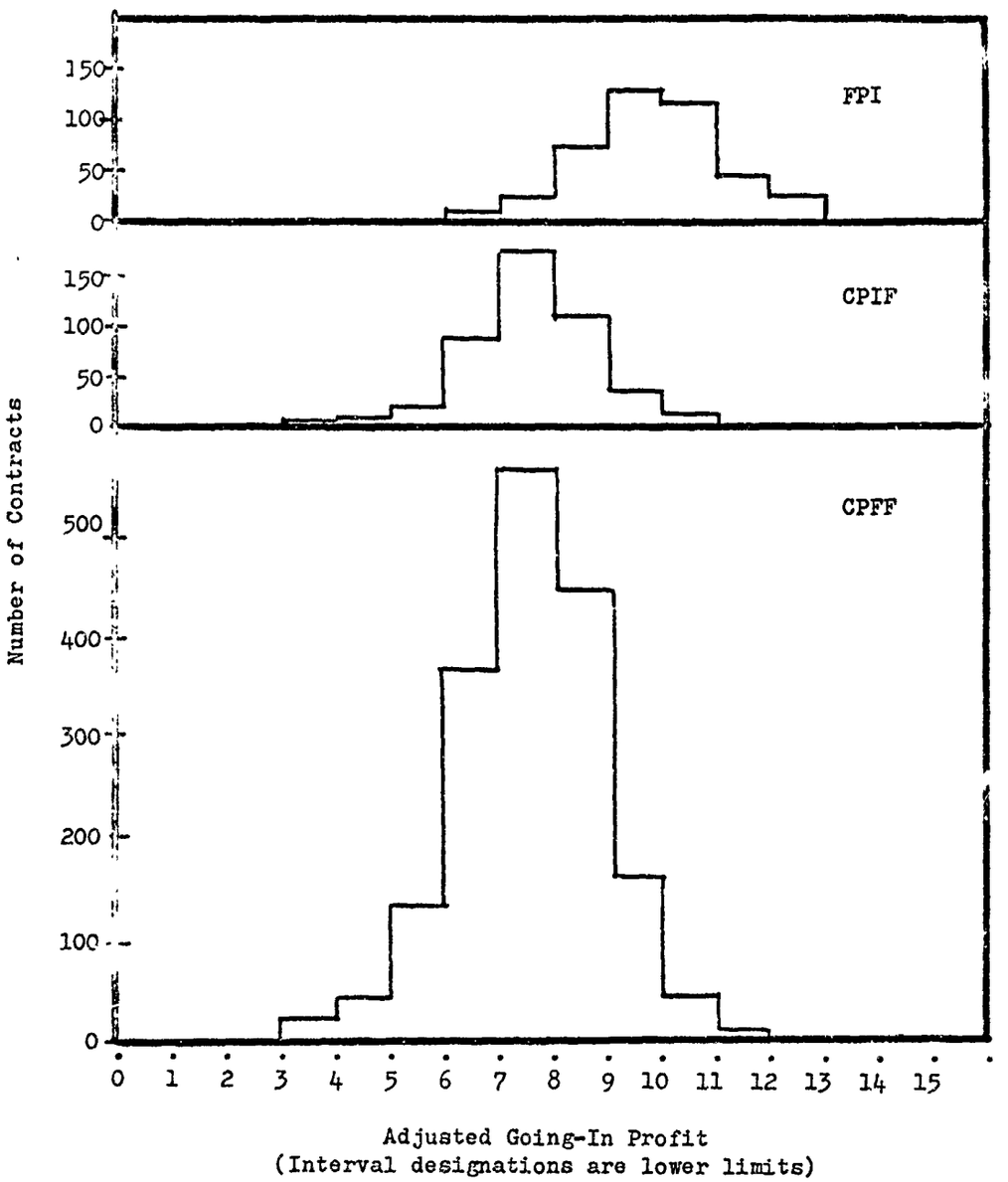
α is the contractor's sharing percentage;

Ca is adjusted contract cost; and

Cf is actual contract cost.

Going-In and Coming-Out Profits for Three Types of Contracts

FPI contracts have average going-in profit rates which appear to be over 2% higher than for CPFF and CPIF contracts. This is shown in Table XIX, which contains a summary of going-in, adjusted going-in, and coming-out profit rates for the 2683 defense contracts examined. Figure 3 contains histograms of going-in profit rates for FPI, CPIF, and CPFF contracts in the sample. The adjusted going-in profit rates for each type of contract in Table XIX show a slight decrease from the initial rate, with a slight increase in the standard deviation for each case.



FPI	0	0	1	0	2	2	9	18	73	131	117	45	28	6	5	2
CPIF	0	1	2	5	8	19	83	171	106	38	11	2	2	0	0	0
CPFF	0	7	6	24	46	136	365	559	439	159	45	7	2	0	1	0

Fig. 3. Distribution of Going-In Profits by Type of Contract.

TABLE XIX

INITIAL, ADJUSTED, AND FINAL PROFIT PERCENTAGES

FOR 2683 FPI, CPIF, AND CPFF CONTRACTS

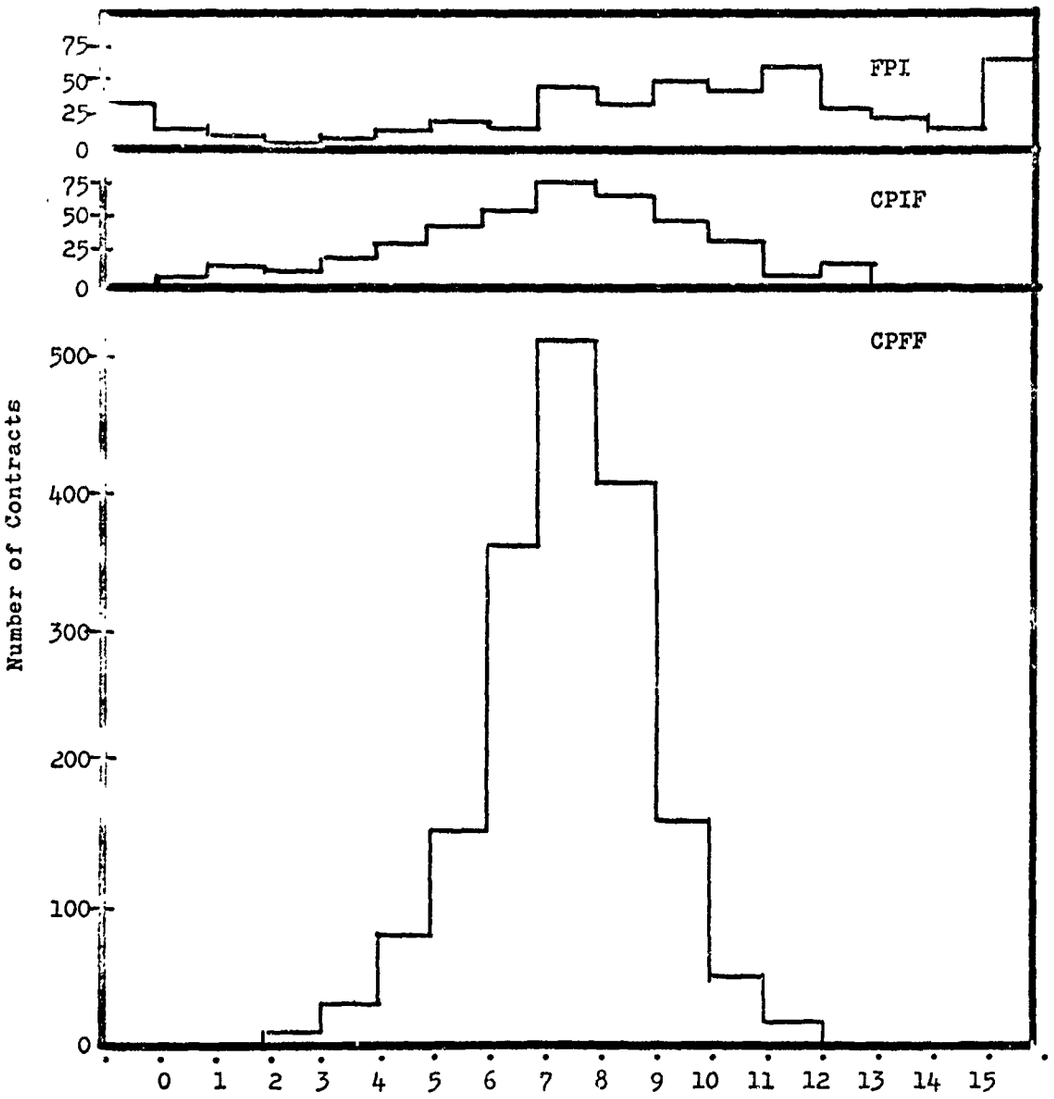
Contract Type	Number	Initial		Adjusted		Final	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
FPI	439	9.84%	1.50%	9.79%	1.53%	8.94%	8.26%
CPIF	448	7.64	1.20	7.52	1.31	7.09	3.11
CPFF	1796	7.59	1.29	7.42	1.43	7.37	1.66

The average coming-out profit rates appear to be close to the going-in rates (±1%). However, the standard deviations of coming-out rates reflect a greater dispersion of individual contract profit rates. The standard deviation of coming-out profit for FPI contracts of 8.26% is over five times greater than for adjusted going-in profit. The 3.11% standard deviation for CPIF contract coming-out profit is over twice as large as for the adjusted going-in profit rate. Figure 4 contains histograms of coming-out profit rates for FPI, CPIF, and CPFF contracts. A comparison of Figures 3 and 4 reveals the relative unchanged nature of CPFF profit rates, and the leveling that occurs for FPI and CPIF coming-out profit rates.

To determine if the apparent differences in going-in and coming-out profit rates are statistically significant, an analysis of variance test was performed.

Analysis of Variance of Going-In and Coming-Out Profits

The null hypothesis of equality of average profit for FPI, CPIF, CPFF contracts and for production and R & D contracts was tested at the



FPI	30	14	9	4	6	14	21	17	42	28	45	38	53	25	22	13	58
CPIF	2	7	18	19	23	29	41	56	76	65	47	29	11	16	3	4	2
CPFF	0	0	7	10	32	71	156	367	513	410	161	48	14	2	1	0	4

Fig. 4. Distribution of Coming-Out Profits by Type of Contract.

1% level of significance. The two-way analysis of variance again eliminated confounding between the factors of contract and work.

The analyses of variance for initial and adjusted going-in profit had similar results. The null hypothesis was rejected for type of contract and type of work, at the 1% level. Thus, there is a significant difference in mean profit between types of contracts, and between production and R & D contracts. However, Table XX c shows the adjusted difference due to type of work to be only 0.28%. The adjusted contract averages are 9.75%, 7.63%, and 7.66% for FPI, CPIF, and CPFF contracts, respectively.

The analysis for coming-out profit shown in Table XXI reveals that the difference in average profit for production and R & D contracts is not statistically significant at the 1% level. The null hypothesis rejection level for this test is 7%. The difference due to type of contract is significant at the 1% level. The average adjusted coming-out profit for FPI contracts is seen in Table XXII c to be 9.04%. CPFF contracts exhibit an average coming-out profit of 7.30%, which is higher than the value of 7.09% for CPIF contracts.

Incentive Contract Profits

The 726 incentive contracts examined in Chapter III are subjected to analysis concerning profits. The groups of contracts are again divided according to contractor's share rate as in the previous analysis.

A two-way analysis of variance was used to test the null hypothesis that the average profit is the same for three different α groups and for two types of work. The results of this analysis are shown in Tables XXII, XXIII, and XXIV. The results for initial and adjusted going-in profit are seen to be practically identical.

TABLE XX

ANALYSIS OF VARIANCE OF GOING-IN PROFIT

AS A PERCENTAGE OF TARGET COST

FOR 2683 FPI, CPIF, AND CPFF CONTRACTS

a. Number, Mean Profit Percentage, and Standard Deviation

Type Contract	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
FPI	363	9.78%	1.55%	76	10.12%	1.20%
CPIF	215	7.32	1.01	233	7.91	1.27
CPFF	486	7.47	1.25	1310	7.64	1.31

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	41.17	41.17 **
Contract	2	1760.98	880.49 **
Interaction	2	15.26	7.63
Within	2677		1.71

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: -0.28%

	FPI	CPIF	CPFF
Adjusted contract means	9.75%	7.63%	7.66%

TABLE XXI

ANALYSIS OF VARIANCE OF COMING-OUT PROFIT

AS A PERCENTAGE OF ACTUAL COST

FOR 2683 FPI, CPIF, AND CPFF CONTRACTS

a. Number, Mean Profit Percentage, and Standard Deviation

Type of Contract	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
FPI	363	9.19%	7.88%	76	7.76%	9.81%
CPIF	215	7.31	2.61	233	6.89	3.46
CPFF	486	7.42	1.62	1310	7.35	1.67

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	49.38	49.38
Contract	2	737.81	368.90 **
Interaction	2	100.59	50.30
Within	2677		14.53

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference due to type of work: 0.31%

	FPI	CPIF	CPFF
Adjusted contract means	9.04%	7.09%	7.30%

TABLE XXII

ANALYSIS OF VARIANCE OF GOING-IN PROFIT

AS A PERCENTAGE OF TARGET COST

FOR 726 INCENTIVE CONTRACTS

a. Number and Mean Profit Percentage

Contractor's Sharing Percentage	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
$\alpha \leq 15\%$	138	7.72%	1.34%	99	8.06%	1.38%
$15\% < \alpha \leq 30\%$	199	9.22	1.66	87	8.73	1.51
$30\% < \alpha$	162	9.53	1.84	41	9.47	1.41

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	0.96	0.96
Share Ratio	2	317.64	158.82 **
Interaction	2	20.36	10.18
Within	720		2.50

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference in mean profit due to type of work: 0.08%

	$\alpha \leq 15\%$	$15\% < \alpha \leq 30\%$	$30\% < \alpha$
Adjusted α group means:	7.87%	9.09%	9.54%

TABLE XXIII

ANALYSIS OF VARIANCE OF ADJUSTED GOING-IN PROFIT

AS A PERCENTAGE OF TARGET COST

FOR 726 INCENTIVE CONTRACTS

a. Number and Mean Profit Percentage

Contractor's Sharing Percentage	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
$\alpha \leq 15\%$	138	7.71%	1.41%	99	8.04%	1.37%
$15\% < \alpha \leq 30\%$	199	9.15	1.67	87	8.61	1.54
$30\% < \alpha$	162	9.52	1.84	41	9.45	1.46

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	1.69	1.69
Share Ratio	2	306.30	153.15 **
Interaction	2	22.40	11.20
Within	720		2.56

** Null hypothesis rejected at the 1% level of significance.

c. Adjustment

Adjusted difference in mean profit due to type of work: 0.11%

	$\alpha \leq 15\%$	$15\% < \alpha \leq 30\%$	$30\% < \alpha$
Adjusted α group means:	7.86%	9.01%	9.54%

The null hypothesis for going-in profit is rejected at the 1% level of significance only for difference in sharing groups. The initial profit rates are 7.87%, 9.09%, and 9.54% for an α of 15% or less, more than 15% but 30% or less, and more than 30%, respectively. The null hypothesis for coming-out profit rates is rejected at the 1% level for sharing groups and for type of work. As shown in Table XXIV c, production contracts average a coming-out profit 1.55% higher than R & D contracts. It is interesting that the middle sharing group, $15\% < \alpha \leq 30\%$, has the highest coming-out profit, 9.79%. The groups having the smallest and largest contractor's sharing rate have very similar coming-out profit rates, 7.13% and 7.58%, respectively.

The fundamental question arises as to the relationship of profit rates, share rates, contract change, and overrun/underrun. Linear regression techniques were used to investigate these relationships.

Regression of Profits, Sharing Rates, and Contract Growth

The relationship between target profit, share rate, and contract growth was investigated using the following regression equations:

$$\text{Change } \% = a + b\,(Pi) + c\,\alpha; \text{ and} \tag{11}$$

$$\text{Overrun } \% = a_1 + b_1\,(Pa) + c_1\,\alpha \tag{12}$$

where Pi is initial contract profit;

Pa is adjusted contract profit;

α is the contractor's sharing percentage; and

a, b, c, a_1, b_1, and c_1 are undetermined regression coefficients.

TABLE XXIV

ANALYSIS OF VARIANCE OF COMING-OUT PROFIT

AS A PERCENTAGE OF FINAL COST

FOR 726 INCENTIVE CONTRACTS

a. Number and Mean Profit Percentage

Contractor's Sharing Percentage	Production			R & D		
	Number	Mean	Std.Dev.	Number	Mean	Std.Dev.
$\alpha \leq 15\%$	138	7.47%	3.02%	99	6.35%	3.46%
$15\% < \alpha \leq 30\%$	199	10.16	4.19	87	7.91	4.14
$30\% < \alpha$	162	7.32	10.61	41	6.30	12.86

b. Adjusted Analysis of Variance

Source of Variation	dof	Sums of Squares	Mean Square
Work	1	363.30	363.30 **
Share Ratio	2	1003.92	501.96 **
Interaction	2	49.51	24.76
Within	720		44.60

** Null hypothesis rejected at the 1% level of significance.

c. Adjustments

Adjusted difference in mean profit due to type of work: 1.55%

	$\alpha \leq 15\%$	$15\% < \alpha \leq 30\%$	$30\% < \alpha$
Adjusted α group means:	7.13%	9.79%	7.58%

Equation 11 gives change as a function of initial target profit and share rate. The 726 incentive contracts were tested first for the total sample, then for two types of work, two types of contracts, and for three groups of sharing rates. The results of these eight tests of equation 11 are summarized in Table XXV. In each of the eight tests no significant relationship between change and going-in profit was found. The results for the coefficient of α were similar to results in Table XV.

The tests for equation 12 on the same eight groups of contracts provided interesting results. The results are shown in Table XXVI. An indication was found that overrun percentage is inversely related to adjusted going-in profit rate. This relationship was found to be significant at less than the 1% level for four of the eight tests. These results are only indicative, and not conclusive. The implication that higher negotiated going-in profit rates are associated with decreased overruns is consistent with DoD pricing theory.

Conclusions

The analysis of defense contract profit relationship presented in this chapter supports the following conclusions:

1. Going-in profit rates on defense contracts are significantly higher for FPI contracts than for cost-plus type contracts (Table XX).

FPI contracts average 9.75% going-in profit and CPFF and CPIF contracts average 7.66% and 7.63%, respectively. This difference between fixed-price and cost-plus type contracts is consistent with DoD profit policy on defense contracts. Since contractors assume more risk under fixed-price type contracts, they are awarded higher going-in profits for fixed-price type contracts than for cost-plus type contracts.

TABLE XXV

REGRESSION COEFFICIENTS FOR EIGHT TESTS WITH GOING-IN PROFIT RATE AND CONTRACTOR'S SHARE RATIO AS THE INDEPENDENT VARIABLES AND CHANGE PERCENTAGE AS THE DEPENDENT VARIABLE

Contract Group	a	b	Standard Error of b	Null Hypothesis Rejection Level	c	Standard Error of c	Null Hypothesis Rejection Level
726 FPI & CPIF	38.83	-0.34	1.43	> 0.50	-0.36	0.15	0.013
499 Production	11.99	1.89	1.43	0.18	-0.25	0.15	0.09
227 R & D	102.62	-6.53	3.52	0.07	-0.43	0.35	0.22
391 FPI	13.36	1.46	1.89	> 0.50	-0.23	0.16	0.16
335 CPIF	11.66	3.28	3.39	0.34	-0.11	0.37	> 0.50
237 $\alpha \leq 15\%$	19.18	2.11	3.75	> 0.50	-0.06	1.27	> 0.50
489 $\alpha > 15\%$	37.80	-0.66	1.47	> 0.50	-0.27	0.16	0.09
203 $\alpha > 30\%$	7.47	2.11	2.20	0.34	-0.16	0.24	0.50

TABLE XXVI

REGRESSION COEFFICIENTS FOR EIGHT TESTS WITH ADJUSTED GOING-IN PROFIT RATE AND CONTRACTOR'S SHARE RATIO AS THE INDEPENDENT VARIABLES AND OVERRUN/UNDERRUN PERCENTAGE AS THE DEPENDENT VARIABLE

Contract Group	a_1	b_1	Standard Error of b_1	Null Hypothesis Rejection Level	c_1	Standard Error of c_1	Null Hypothesis Rejection Level
726 FPI & CPIF	22.32	-2.12	0.476	< 0.001	0.08	0.049	0.100
499 Production	13.36	-1.74	0.44	< 0.001	0.18	0.04	< 0.001
227 R & D	37.26	-2.80	1.23	0.024	-0.07	0.12	> 0.500
391 FPI	3.32	-1.47	0.51	0.004	0.42	0.04	< 0.001
335 CPIF	24.29	-0.66	1.14	> 0.500	-0.67	0.12	< 0.001
237 $\alpha \leq 15\%$	38.08	-0.79	1.31	> 0.500	-2.16	0.45	< 0.001
489 $\alpha > 15\%$	0.98	-1.21	0.39	0.002	0.40	0.04	< 0.001
203 $\alpha > 30\%$	-21.39	-0.60	0.66	0.370	0.71	0.07	< 0.001

2. Production contracts average slightly less going-in profit than do R & D contracts (Table XV).

This conclusion is consistent with DoD profit policy on defense contracts. R & D work normally involves greater uncertainty than production work. The risks inherent in R & D work result in higher going-in profit rates for contractors willing to undertake such work.

3. Coming-out profit rates on defense contracts are significantly higher for FPI contracts than for cost-plus type contracts (Table XXI).

The coming-out profit for FPI, CPIF, and CPFF contracts is 9.04%, 7.09%, and 7.30%, respectively. However, the standard deviation of average coming-out profit for FPI contracts is larger than for either CPIF or CPFF contracts. This larger standard deviation indicates a significantly wider range of individual contract profit outcomes for FPI contracts. The fact that CPFF contracts have a higher coming-out profit than CPIF contracts raises a question as to the effectiveness of incentive provisions in the sample of CPIF contracts.

4. Contractor share rates higher than 30% have not generally resulted in higher average coming-out profits for contractors (Table XXIII and Table XXIV).

The initial going-in profit rates for small, medium, and large contractor share rates are 7.87%, 9.09%, and 9.54%, respectively. The adjusted going-in rates are nearly identical to the initial rates. However, the coming-out profit rates are 7.13%, 9.79%, and 7.58% for small, medium, and large contractor share rates, respectively.

5. Production contracts containing cost incentive provisions generally average larger coming-out profit rates than R & D contracts (Table XXIV).

This conclusion may reflect the existence of technical uncertainty

in the type of work accomplished using R & D contracts.

6. Defense incentive contract cost growth resulting from changes in the scope of the contract is not significantly related to the initial going-in profit rate (Table XXV).

The insensitivity of contract change to the initial negotiated going-in profit is reflected in this conclusion.

V. Summary of Conclusions, Observations, and Recommendations

Summary of Conclusions

The following conclusions were drawn from the analysis of defense contract outcomes in Chapters III and IV:

No meaningful relationship exists between overrun/underrun and contract change.

Significant difference in average overrun/underrun exist for types of contracts and types of work.

Generally, the contract change percentage of incentive contracts tends to decrease as the contractor's share rate increases.

Contracts with large contractor share rates ($\alpha > 15\%$) tend to overrun.

Contractors tend to earn performance incentives, regardless of contract cost outcome.

Underruns tend to be associated with early product delivery, and overruns tend to be associated with late product delivery.

Going-in profit rates on defense contracts are significantly higher for FPI contracts than for cost-plus type contracts.

Production contracts average slightly less going-in profit than do R & D contracts.

Coming-out profit rates on defense contracts are significantly higher for FPI contracts than for cost-plus type contracts.

Contractor share rates higher than 30% have not generally resulted in higher average coming-out profits for contractors.

Production contracts containing cost incentive provisions generally average larger coming-out profit rates than R & D contracts.

Defense incentive contract cost growth resulting from changes in the scope of the contract is not significantly related to the initial going-in profit rate.

The conclusions summarized above were previously presented in Chapters III and IV. A brief discussion of their implications concludes each chapter.

Observations

The first step in gaining an understanding of today's defense procurement process is to look back at the historical origins of this process. The system of weapons acquisition in use today in the United States has evolved through necessity. This was evident at each stage of this nation's growth from a colonial union to a world power.

The U.S. has historically depended on private enterprise to provide military hardware. The limited numbers of government owned and operated shipyards and arsenals have traditionally faced competition from the private sector. The Civil War projected the United States Government into the role of a major customer for military equipment. The contract for the warship Merrimack contained a provision that allowed the contractor to increase his profit through successful production. This negotiated contract highlights the early use of an incentive contract.

The U.S. entry into World War I again forced the national Government to meet emergency conditions with emergency defense measures. Private industry was called on to meet wartime needs, but the terms were determined primarily by the Government.

During World War II, the Government acted as national coordinator of defense production, and again assumed the role of a customer of private industry. Formal advertising was replaced during the war by negotiated contracting. The renegotiation of contract prices was introduced during these years.

Following World War II, the increased threat to national security prompted the establishment of a lasting defense capability. Congressional action formed the basis for a permanent and fully regulated process of organization for national defense.

The rapid changes in technology following World War II caused a defense industry to develop. This industry became very specialized and complex. The process of defense contracting became more complex, also. The use of artificial incentives in contracts to replace the competition of the marketplace has become accepted because of the specialized nature of the defense industries.

In the early 1960's, an attempt was made to improve economy in defense procurement through increased use of firm fixed-price and incentive type contracts. This has been previously identified as the "incentive era".

In the first chapter, some specific questions were proposed that were intended to direct this research. These questions were directed toward contract growth outcomes, contract profit outcomes, incentive combination outcomes, and extracontractual costs and benefits of the

"incentive era".

An examination of a large number of recent defense contracts revealed no significant relationship between authorized contract changes and overruns/underruns. This result does not support the theory that contractors may attempt to reduce potential overruns by increasing target costs through changes in the scope of the contract.

The three types of contracts examined in this analysis have significantly different results in terms of contract change. As expected, CPFF contracts have the largest change, and FPI contracts have the least change. This is consistent with their use according to conditions of contract uncertainty.

Overruns were significantly larger for CPIF contracts than for FPI or CPFF contracts. R & D contracts were found to have larger overruns than production contracts. Since both R & D work and work done under cost-plus type contracts is normally subject to greater uncertainty, this result is not surprising. However, the results for difference in overrun between CPIF and CPFF contracts conflicts with incentive theory. CPIF contracts would be expected to have less overrun than CPFF contracts.

Generally, it was found in this research that the contract change percentage of incentive contracts tends to decrease as the contractor's share rate increases. This result does not support the theory that contractors with a large responsibility for cost attempt to recoup losses through changes to the contract. Actually, contractors with large share rates demonstrated a tendency to generally have cost overruns.

No significant difference was detected in change percentages for production and R & D contracts. However, production contracts did

exhibit significantly less overrun than R & D contracts. This is probably explained by the greater uncertainty associated with R & D contracts.

The question of differences in average profit between types of contracts was examined in this research. Both going-in and coming-out average profits for FPI contracts were found to be significantly higher than for cost-plus type contracts. This is consistent with the theory of incentive contracting. Fixed-price type contracts with incentive provisions are intended to provide greater rewards to contractors who assume greater responsibility for costs. Production contracts were found to average slightly less going-in profit than R & D contracts. Coming-out profit for production incentive contracts was found to be higher than for R & D contracts. These results again are probably related to the greater uncertainty inherent in research and development work.

Contracts with multiple incentives are by their nature complex. This research only provides a qualitative statement concerning contracts having multiple incentives. Contractors tend to earn performance incentives, regardless of the cost outcome of the contract. This observation probably indicates that extracontractual factors influence contractor performance. The fact that a quality product appears to be more important to contractors than cost considerations suggests that reputation, follow-on work, and prestige may affect contract outcomes.

Recommendations

1. Additional efforts must be made to identify and eliminate the causes of improper contract selection and structuring.

2. In structuring contracts with multiple incentives, contracting officers should be aware that cost incentives and performance or schedule incentives may not be independent.

3. Two suggestions for further study resulted from this research. First, a similar study should be performed on small defense contracts, i.e., less than $200,000. This group of contracts may exhibit characteristically different results than for large contracts. In any event, these smaller contracts comprise a significant share of procurement effort and should not be ignored. Second, the DoD contract summary affords the opportunity to compare contract outcomes for defense contractors. This type of study could provide an interesting insight into the characteristics of the defense industry.

Concluding Comments

The fact that this nation has successfully preserved its way of life over nearly two centuries is a tribute to the citizens who produce, procure, use, and pay for defense goods and services. There are deficiencies in the defense procurement system. The effort to correct these deficiencies is sincere and continual. This was shown by the recent emphasis that the Secretary and Deputy Secretary of Defense placed on the implementation of the recommendations of a Blue Ribbon Defense Panel appointed by the President. This panel recommended a major overhaul of defense procurement methods. Many of these recommendations are included in the DoD fly-before-you-buy policy outlined previously (Ref 36:39).

There are many factors which influence defense procurement that were left untreated in this research. One aspect that should be mentioned is the Government's ability, by law, to renegotiate coming-out profits for

defense contracts. Renegotiation Acts have been passed by Congress since 1942. These laws allow a government board to make determinations of excessive profits of defense contractors (Ref 12:27).

Throughout this research the intent was not to find fault, but to objectively examine the results of increased emphasis on incentive contracting. The superior defense capability that the United States has today has in part resulted from active pursuit of improved defense procurement methods. The nature of today's defense needs challenge those responsible for defense procurement more than at any previous time. The ultimate test of our defense procurement system is how well it succeeds in providing the goods and services for deterring a potential enemy. In this respect it has been very successful to date.

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Appendix A

Representative Previous Research Studies Concerning Incentive Contracting

Representative Previous Research Studies Concerning Incentive Contracting

Author	Report Name	Date Issued	Comment
General Accounting Office	Defense Industry Profit Study (Ref 32)	March 1971	Study of profits earned on negotiated contracts and subcontracts entered into by DoD, NASA, Coast Guard, and AEC. 74 large contractors were chosen by GAO to submit data on profits for the years 1966 through 1969.
Logistics Management Institute	Defense Industry Profit Review 1968 Profit Data (Ref 18)	March 1970	Profit Review of 68 companies with $1 million or more in government business. Similar profit reviews are available for 1966 and 1967 profit data.
David Leigh Belden, Stanford University	Defense Procurement Outcomes in the Incentive Contract Environment (Ref 3)	May 1969	Analysis of DoD and NASA use of incentive contracts, comparing government business profits, and examining 834 defense contract outcomes.
Irving N. Fisher; Rand Corporation	A Reappraisal of Incentive Contracting Experience (Ref 7)	July 1968	Analysis of 1007 Air Force Contracts, covering the period fiscal year 1959 through 1966.
Irving N. Fisher; Rand Corporation	Cost Incentives and Contract Outcomes: An Empirical Analysis (Ref 9)	September 1966	Analysis of 525 selected contracts covering the period 1959 - 1963.

Appendix A

Frederic M. Scherer; Princeton University	The Weapons Acquisition Process: Economic Incentives (Ref 29)	1964	Examination of 12 advanced weapons system and 7 commercial product acquisitions using case studies and related data.

Appendix B

Basic Types of Procurement Contracts

(Source: Ref 42)

Appendix B-1

Firm Fixed-Price Contract (FFP)

Application. The firm fixed-price type of contract is recommended when performance has been demonstrated and cost and technological uncertainty is low.

Elements. The following elements apply to FFP contracts:

Contract Price - This applies to the price agreed to by the customer and contractor and is unchanged throughout the life of the contract.

Characteristics. The firm fixed-price contract requires the contractor to accept full cost responsibility and his final cost in turn determines his final profit. The effectiveness of the contractor in total management of the contract theoretically determines the existence and size of profit or loss on the contract.

Appendix B-1

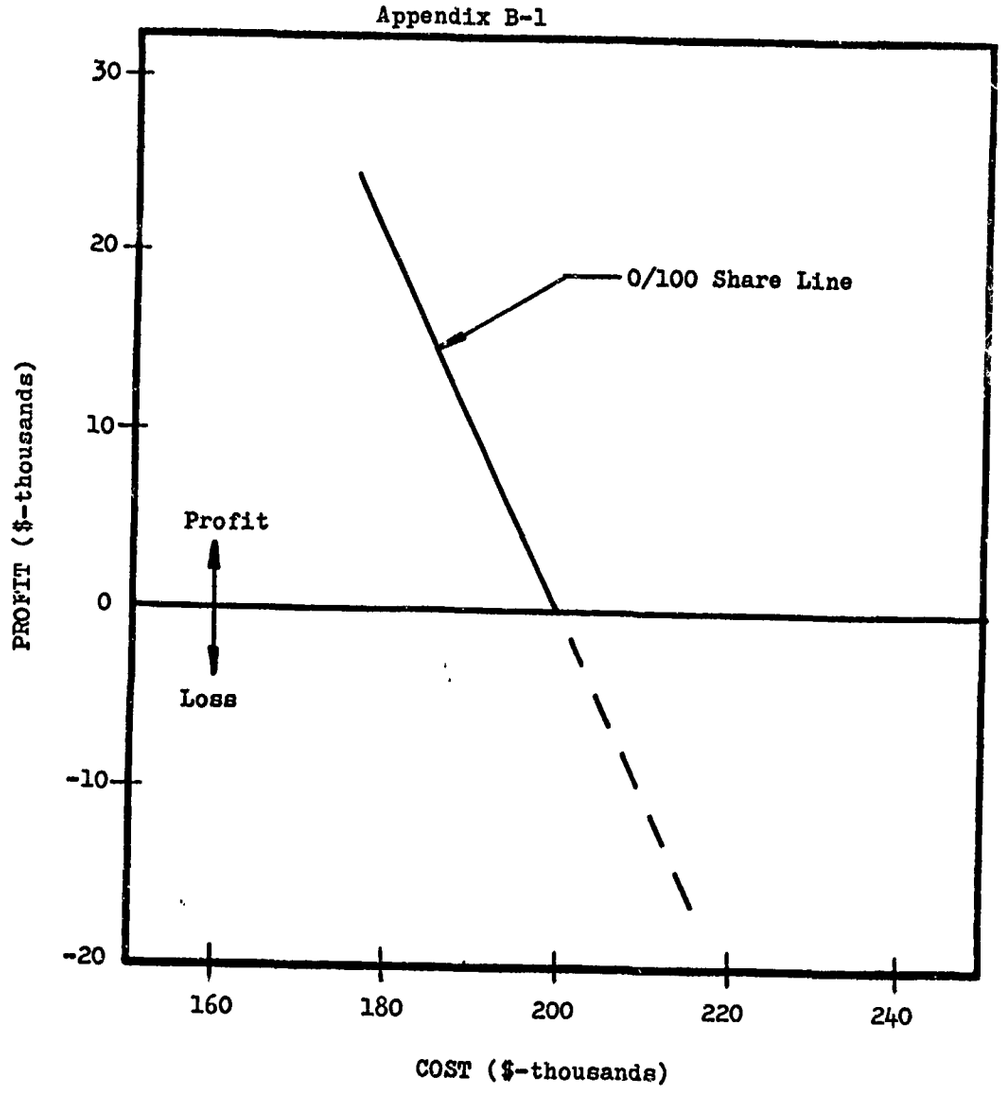

Fig. 5. Firm Fixed-Price Contract Cost-Profit Curve.

	Example		
	1	2	3
Contract Price	$200,000	$200,000	$200,000
Final Cost	185,000	200,000	215,000
Final Profit	15,000	-0-	(15,000)
Final Profit %	8.11%	0%	-6.98%

Appendix B-2

Fixed-Price Incentive Contract (FPI)

Application. The fixed-price incentive contract can be structured to provide incentive provisions for cost only, or for cost, product performance, and/or schedule. The FPI contract with only a cost incentive provision is recommended when confidence in achieving contract performance is high, but some uncertainty as to technology or cost does reasonably exist. The FPI contract with multiple incentive provisions is recommended when improvement in contract performance is desired, and some uncertainty as to technology or cost does reasonably exist.

Elements. The following elements apply to FPI contracts:

Target Cost - an estimate of final contract cost with theoretically equal probability of overrun or underrun.

Target Profit - a reasonable profit for target cost at target performance.

Target Price - target cost plus target profit.

Ceiling Price - the total dollar amount for which the customer will accept liability. This ceiling price in turn helps define the Point of Total Assumption (PTA). Exceeding the PTA in effect causes the contract to revert to a FFP contract.

Share Ratio - a descriptive formula reflecting a joint responsibility for costs. A share ratio of 70/30 indicates that 70% of any dollar difference between target and final cost is the responsibility of the customer, and 30% is the responsibility of the contractor.

Characteristics. The fixed-price incentive contract theoretically allows the customer to structure incentive provisions which communicate to the contractor the areas in which the customer desires improved contract performance. It differs from the FFP contract in that the customer assumes joint responsibility for risk up to the ceiling price.

Appendix B-2

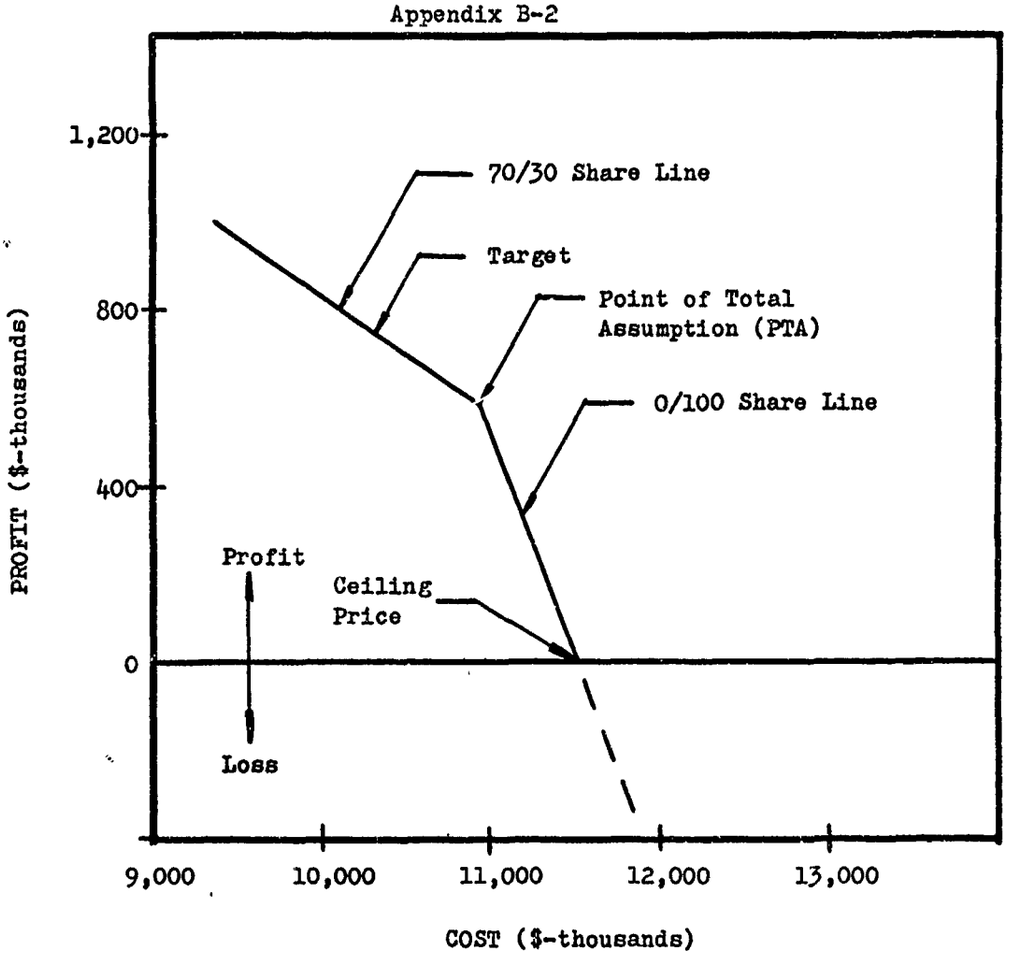

Fig. 6. Fixed-Price Incentive Contract Cost-Profit Curve.

	Example - Share Ratio 70/30		
	1	2	3
Target Cost	$10,000,000	$10,000,000	$10,000,000
Target Profit	850,000	850,000	850,000
Target Price	10,850,000	10,850,000	10,850,000
Ceiling Price	11,500,000	11,500,000	11,500,000
Final Cost	9,600,000	11,775,000	10,500,000
Final Profit	970,000	(275,000)	700,000
Final Price	10,570,000	11,500,000	11,200,000
Final Profit %	10.10%	-2.34%	6.67%

Appendix B-3

Cost-Plus-Incentive-Fee Contract (CPIF)

Application. The cost-plus-incentive-fee contract can be structured to provide incentive provisions for cost only, or for cost, product performance, and/or schedule. The CPIF contract with only a cost incentive provision is recommended when a given level of contract performance is desired and confidence in achieving that performance level is high, but where uncertainty in technology or cost is too high to allow use of a fixed-price incentive contract. The CPIF contract with multiple incentive provisions is recommended when conditions are similar to the above, but the customer desires improvement over some given level of performance.

Elements. The following elements apply to CPIF contracts:

Target Cost - the most probable cost for target performance.

Target Fee - a reasonable fee for target performance.

Maximum Fee - upper limit of fee based on the most pessimistic estimate of cost.

Minimum Fee - lower limit of fee based on the most optomistic estimate of cost.

Range of Incentive Effectiveness (RIE) - the range from most optomistic to most pessimistic cost over which an incentive provision is effective.

Share Ratio - a descriptive formula reflecting a joint responsibility for costs. A share ratio of 70/30 indicates that 70% of any dollar difference between target and final cost is the responsibility of the customer, and 30% is the responsibility of the contractor.

Characteristics. The cost-plus-incentive-fee contract theoretically allows the customer to structure incentive provisions which communicate to the contractor the areas in which the customer desires improved contract performance. It differs from the FPI contract because there is no price ceiling, but a range of incentive effectiveness is specified.

Appendix B-3

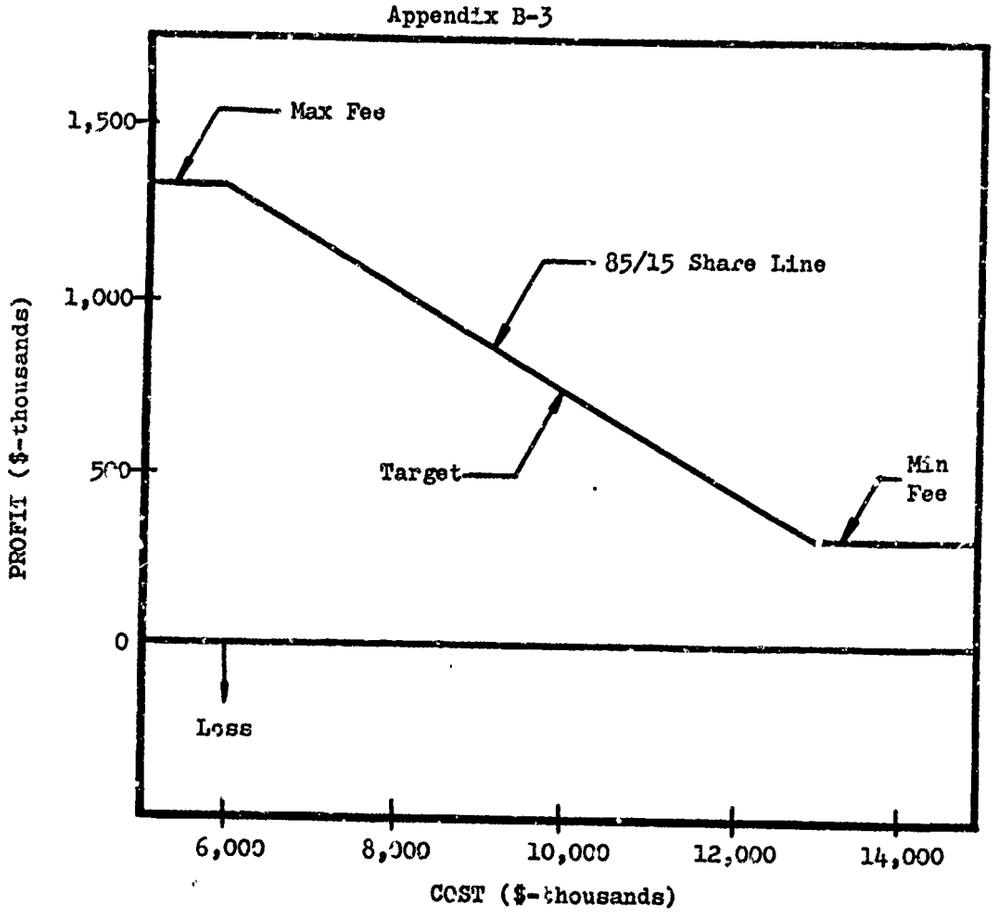

Fig. 7. Cost-Plus-Incentive-Fee Contract Cost-Profit Curve

Example

(Share Ratio 85/15 over Range of Incentive Effectiveness)

	1	2	3
Target Cost	$10,000,000	$10,000,000	$10,000,000
Target Fee	750,000	750,000	750,000
Final Cost	9,000,000	10,000,000	15,000,000
Final Fee	900,000	750,000	300,000
Final Price	9,900,000	10,750,000	15,300,000
Final Fee %	10.0%	7.5%	2.0%

Appendix B-4

Cost-Plus-A-Fixed-Fee Contract (CPFF)

Application. The cost-plus-a-fixed-fee contract is recommended when a given level of effort is required or where uncertainty regarding technology or cost is extremely high.

Elements. The following elements apply to CPFF contracts:

Estimated Cost - the most probable cost for total effort.

Fixed Fee - an amount agreed upon by the customer and contractor as reasonable to be paid to the contractor by the customer, regardless of the final cost.

Characteristics. The cost-plus-a-fixed-fee contract requires the customer to accept full cost responsibility, while the contractor's profit is in effect the fixed fee. The CPFF contract theoretically allows the contractor minimum cost responsibility, and thus, a minimum incentive to control costs.

Appendix B-4

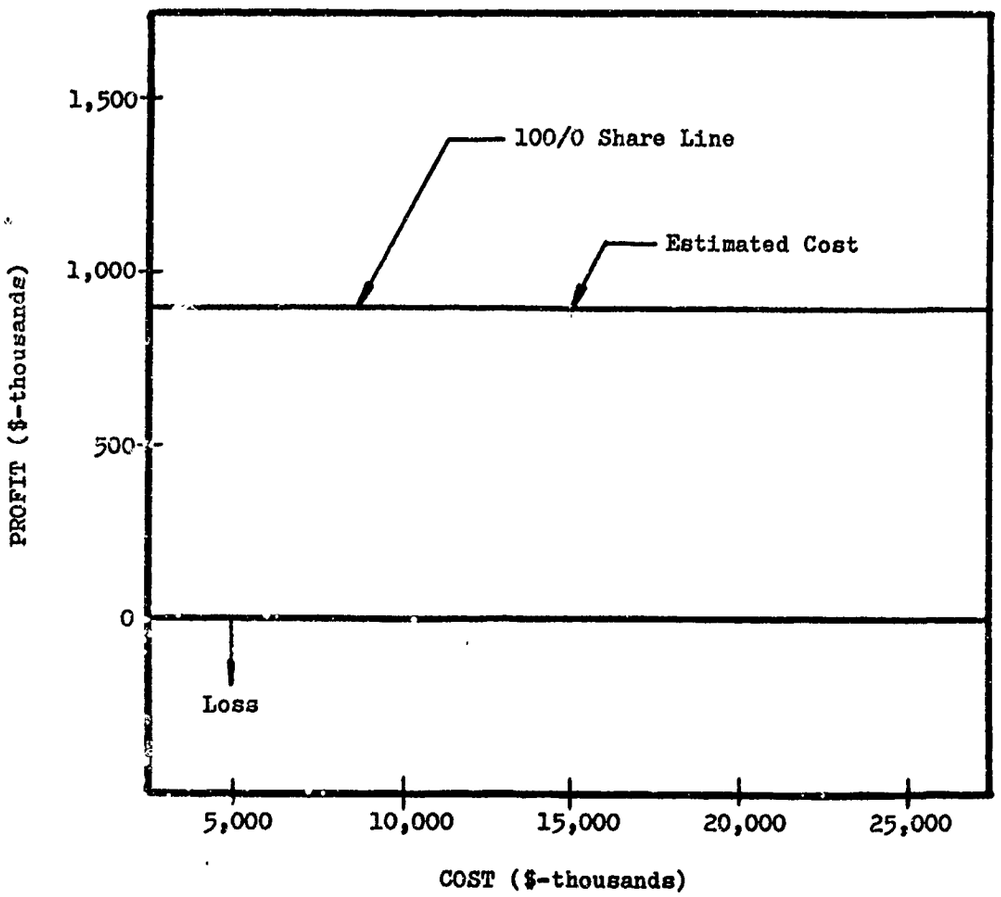

Fig. 8. Cost-Plus-A-Fixed-Fee Contract Cost-Profit Curve.

	Example		
	1	2	3
Estimated Cost	$15,000,000	$15,000,000	$15,000,000
Fixed Fee	900,000	900,000	900,000
Final Cost	12,000,000	15,000,000	20,000,000
Final Fee	900,000	900,000	900,000
Final Price	12,900,000	15,900,000	20,900,000
Final Fee %	7.5%	6.0%	4.5%